This study was designed to reveal the outcomes of participation in science project activities such as Science Fair projects among ninth grade science students in Multnomah County, Oregon, during the second half of the 1963-1964 school year.

A stratified sample of five public schools was selected to participate in this study. The total sample numbered 952.

Students were pre-tested in January to control previous achievement and interest in science and post-tested in May to determine subgroup differences. Instruments utilized were: the STEP Science Test, Form 3A; the STEP Science Test, Form 2B; and the Occupational Interest Inventory, Intermediate Battery, 1956 Revision. The Student Rating Scale was given to determine the teachers' pre-rating of the students. The Teacher Inventory and the Student Inventory

Redacted for privacy

Stanley E. Williamson
were given to determine involvement in science project activities.

General intelligence was controlled by obtaining IQ scores secured earlier in the year.

Students were stratified for experience in science project making, choice of science as a career, type of project made, type of award received, career choice, record of project making, teacher-school motivational factors, student motivational factors, and reaction to project making.

The data were analyzed by the analysis of covariance and by descriptive percentages.

The following major conclusions were drawn from the data obtained in this study:

1. Science project making was not proven as significantly contributing to a student's achievement in science or increase in science interest as measured by standardized tests.

2. Students who chose science as a career were not proven as significantly superior in science achievement or science interest as measured by standardized tests.

3. Students who made science projects and/or who chose science as a career were not shown to receive significantly higher ratings from a teacher who considers project making a valuable activity.
4. Students who made investigation type projects excelled in achievement over students who made construction projects but did not excel over students who made demonstration or no project at all as measured by standardized tests. This inconsistency suggests further study.

5. The type of project made was not proven as significantly contributing to a student's interest in science as measured by standardized tests.

6. The Science Fair type of award for project making was not proven as significantly contributing to the student's achievement or interest in science as measured by standardized tests.

7. The larger the number of years that the student participated in project activities the greater the possibility that he has chosen science as a career and the lesser the possibility that he has chosen personal-social or mechanical careers. The data does not reveal whether the career orientation resulted from the project activity or vice versa.
THE OUTCOMES OF PARTICIPATION IN SCIENCE PROJECT ACTIVITIES AMONG NINTH GRADE SCIENCE STUDENTS IN MULTNOMAH COUNTY, OREGON

by

JAMES ROBERT HALE

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

DOCTOR OF EDUCATION

June 1967
APPROVED:

Redacted for privacy

Professor of Science Education
in charge of major

Redacted for privacy

Dean of the School of Education

Redacted for privacy

Dean of Graduate School

Date thesis is presented May 5, 1945

Typed by Joanne Wenstrom for James Robert Hale
ACKNOWLEDGMENTS

The writer wishes to express his appreciation to the many individuals who have assisted in this investigation. Special thanks are due to the members of his graduate committee and to the following:

To Dr. Stanley Williamson and Dr. Fred Fox for their continual guidance and constructive criticism of the thesis.

To Dr. George Ingebo and Dr. Chadwick Karr for assistance concerning the design of the study and statistical procedures.

To Mr. Raymond Barrett for counsel and constructive criticism of the study.

To the teachers, students, and administrators of the five schools whose cooperation made this study possible.

To the faculty and staff of the School of Education at Portland State College who contributed invaluable assistance in the preparation of the thesis.

Finally, to my wife, family and friends for their faith and understanding.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>INTRODUCTION</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>The Problem</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Statement of the Problem</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Significance of the Study</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Hypotheses</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Definition of Terms</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Basic Assumptions</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Procedures</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Sample Selection</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Sources of Data</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Administration and Scoring of the Instruments</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Analysis of the Data</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Delimitation of the Problem</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II</th>
<th>BACKGROUND AND RELATED LITERATURE</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Objectives and Outcomes</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Interest</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Award Programs and Science Fairs</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Project Method</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>III</th>
<th>DESIGN OF THE STUDY</th>
<th>39</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample Selection</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Experimental Design</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Statistical Tests</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Selection of Instruments</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>The STEP Science Test</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>The Occupational Interest Inventory</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>The Teacher Inventory</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>The Student Inventory</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>The Student Rating Scale</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Tests of Intelligence</td>
<td>53</td>
</tr>
</tbody>
</table>
Chapter IV  THE STUDY

Experience in Project Making 59
   Sample Selection 59
   Achievement 60
   Interest 63

Career Choice 65
   Sample Selection 65
   Achievement 67
   Interest 68
   Teacher Ratings 70

Type of Project 73
   Sample Selection 73
   Achievement 75
   Interest 80

Motivation Factors: Awards 81
   Sample Selection 81
   Achievement 83
   Interest 85

Motivation Factors 85
   Teacher-School Motivation Factors 87
   Student Motivation Factors 91
   Students’ Reactions 94
   Career Choice and Project Record 96

V SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 99
   Summary 99
   Conclusions 102
   Recommendations 104

BIBLIOGRAPHY 108

APPENDIX 115
LIST OF TABLES

Table  I  Degree of participation in Science Fair activities and enrollments for the ninth grade classes in the sample schools during 1963.  

II  List of fundamental knowledge areas and reasoning abilities prepared by the test-construction committee for the STEP science test.  

III  Number of students making projects by grade level.  

IV  Summary of experimental achievement data for ninth grade project groups stratified for experience in project making.  

V  Summary of experimental interest data for ninth grade project groups stratified for experience in project making.  

VI  Subclasses for teacher (X) according to grade in which project was made and science career choice.  

VII  Summary of experimental achievement data for ninth grade project groups stratified for career choice.  

VIII  Summary of experimental interest data for ninth grade project groups stratified for career choice.  

IX  Summary of experimental teacher rating data for ninth grade project groups stratified for career choice.
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Number of students making projects by type of project made.</td>
<td>75</td>
</tr>
<tr>
<td>XI</td>
<td>Summary of experimental achievement data according to type of project made.</td>
<td>76</td>
</tr>
<tr>
<td>XII</td>
<td>Summary of experimental achievement data of criterion and adjusted criterion means according to type of project made.</td>
<td>78</td>
</tr>
<tr>
<td>XIII</td>
<td>Summary of experimental interest data according to type of project made.</td>
<td>82</td>
</tr>
<tr>
<td>XIV</td>
<td>Number of students making projects by type of awards received.</td>
<td>83</td>
</tr>
<tr>
<td>XV</td>
<td>Summary of experimental achievement data according to awards received.</td>
<td>84</td>
</tr>
<tr>
<td>XVI</td>
<td>Summary of experimental interest data according to awards received.</td>
<td>86</td>
</tr>
<tr>
<td>XVII</td>
<td>Relationship of teacher-school motivation factors and ninth grade project makers.</td>
<td>90</td>
</tr>
<tr>
<td>XVIII</td>
<td>Relationship of students who made ninth grade projects, students who did not make ninth grade projects and student motivation factors.</td>
<td>93</td>
</tr>
<tr>
<td>XIX</td>
<td>Students' reactions to project making.</td>
<td>95</td>
</tr>
<tr>
<td>XX</td>
<td>Relationship of students' project record and students' career choice.</td>
<td>98</td>
</tr>
</tbody>
</table>
Among the current philosophies of science education, the most common foundation on which objectives are based regards science as an enterprise involving both a process and a product. Present day leaders in science education state their objectives in terms of processes and products. These common general objectives are attacked in various ways but one popular avenue is the science project which is often motivated by a Science Fair. The Oregon Museum of Science and Industry (OMSI) began sponsoring and expanding the Science Fair movement from a local to a regional basis in 1953 and at that time 200 students participated in preparing projects. In 1962 nearly 100,000 students exhibited projects in the Northwest region (57, p. 2).

There is a relationship between the general objectives of science education as stated by the Educational Policies Commission
(21, p. 133) and the objectives of the Science Fair movement as proposed by OMSI. The OMSI objectives are stated as follows (57, p. 2):

The Science Fair movement has vast educational and scientific implications:

1. It gives young people an opportunity to develop and extend their interest in science.

2. It enables students to discover and appreciate through personal experience some of the problems of research.

3. It encourages an inquiring mind, ingenuity, resourcefulness.

4. It provides an outlet for enthusiasm and the craving for an activity that yields results.

5. It helps develop the habit of persistence regardless of initial success.

6. It brings to light qualities and abilities that otherwise might not be discovered.


8. It helps overcome one of the greatest problems in our country today —— the scientific illiteracy of its people.

9. It helps students to work as scientists do, and teaches them through their work the joy of finding out something for themselves.

The above objectives may be classified in terms of the processes and the products of science and interest in science which make up the scientific enterprise. The question concerned with in
this study is whether or not participation in science project making helps the student toward the attainment of these objectives.

**Significance of the Study**

A great deal of time, energy, and finance are required to implement, exhibit, and evaluate 100,000 projects. A worthwhile contribution to the field of science education could be made if one could assess the contribution of project making and of Science Fair participation to the objectives of science education. The study will attempt:

1. To provide data on whether or not the making of a science project increases the student's understanding of the processes, products, or increased interests in science. If participation in project making brings about significant changes in students, then teachers should be encouraged to employ this device. If participation in project making does not bring about significant changes in students then the schools may wish to reassess the value of participating in this program.

2. To provide data on the ninth grade Science Fair winners. If successful participation in a Science Fair is a sign of educational advancement, can the winners be identified by their interest ratings or achievement test scores of both
process and product? In the search for science talent, it would be useful if teachers had some readily available data as a predictive device in order to properly counsel potentially successful science students who may otherwise be unidentified.

3. To provide data on the type of project participation. Student projects may be classified as investigations of a problem, construction type projects, and demonstrations or illustrations. Is participation in all of these kinds of projects of equal value in the pursuit of the objectives of science education? If one type of project is more valuable than another, then teachers may wish to encourage students to participate in the more useful experience.

4. To provide data on the relationship between consistency of participation in science project making and the student's career choice. Is project making correlated with a desire to pursue a science career? If so, possibly project making plays some interest or motivating role independent of currently measurable outcomes and thus should be encouraged.

5. To provide data on the effect of certain factors motivating a student to make a project. If certain motivating factors are inhibiting or encouraging such information would be
useful if one knows the effects of project making.

**Hypotheses**

Specifically this study is designed to test the following hypotheses:

1. Students who made projects did not differ in achievement from students who did not make projects, with pretest and IQ scores held constant.

2. Students with previous project making experience did not differ in achievement from students without previous project making experience, with pretest and IQ scores held constant.

3. Students who made projects did not differ in achievement from students who did not make projects whether they had previous experience in project making or did not have previous experience in project making, with pretest and IQ scores held constant.

4. Students who made projects did not differ in science interest from students who did not make projects, with pretest and IQ scores held constant.

5. Students with previous project making experience did not differ in science interest from students without previous project making experience, with pretest and IQ scores held constant.
6. Students who made projects did not differ in science interest from students who did not make projects whether they had previous experience in project making or did not have previous experience in project making, with pretest and IQ scores held constant.

7. Students who made projects did not differ in achievement from students who did not make projects, with pretest, IQ scores, experience, teacher, and school held constant.

8. Students who chose science careers did not differ in achievement from students who did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

9. Students who made projects did not differ in achievement from students who did not make projects whether they chose science careers or did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

10. Students who made projects did not differ in science interest from students who did not make projects, with pretest, IQ scores, experience, teacher, and school held constant.

11. Students who chose science careers did not differ in
science interest from students who did not choose science careers, with pretest, IQ scores, experience, teacher and school held constant.

12. Students who made projects did not differ in science interest from students who did not make projects whether they chose science careers or did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

13. Students who made projects did not differ in teacher ratings from students who did not make projects, with pretest, IQ scores, experience, teacher, and school held constant.

14. Students who chose science careers did not differ in teacher ratings from students who did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

15. Students who made projects did not differ in teacher ratings from students who did not make projects whether they chose science careers or did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

16. Students who made investigation projects, construction projects, demonstration projects, or none at all did not
differ in achievement, with pretest and IQ scores held constant.

17. Students who made investigation projects, construction projects, demonstration projects, or none at all did not differ in science interest, with pretest and IQ scores held constant.

18. Students who received Science Fair recognition awards did not differ in achievement from students who received participation awards, no awards, or who did not make projects, with pretest and IQ scores held constant.

19. Students who received Science Fair recognition awards did not differ in science interest from students who received participation awards, no awards, or who did not make a project, with pretest and IQ scores held constant.

Definition of Terms

Types of Fairs. A school may choose to conduct an organized and sponsored Science Fair as defined by OMSI (57, p. 2) or it may choose to hold class or school displays. The school display is not sponsored by OMSI and participants usually do not receive awards.

The types of Science Fairs and displays are defined as follows:

1. Class or School Display: Each teacher or school sponsors its own display of projects. No awards are given and
projects are not judged.

2. Local School or District Fair: Each school, or possibly a whole district, holds a Science Fair for students in that school or schools. Projects are judged, and the outstanding projects sent on to a county or regional Science Fair.

3. County or Regional Fairs: The Northwest is grouped into larger districts by counties or by regions. A region may be a single large district that has so many participants (over 2000) that it is large enough to host its own regional. In most cases, however, county fairs are held for winners of local school fairs. The projects are judged, and the winners selected.

4. Northwest Science Fair: This is an exhibit of winners selected from the counties and regions throughout the Northwest. Intermediate, juniors and senior division winners of the county or regional fairs are invited to present their project orally before judges at the Northwest Science Fair in Portland as part of the Northwest Science Youth Congress.

Type of Project. The types of projects are defined by OMSI (57, p. 18) as follows:

A. Investigation - Research: Here the student picks a problem to which he does not know the answer, or at least he
is in doubt as to the exact nature of the answer. The student sets up his own experimentation-observation type of project. From data he has collected, the student attempts to draw a valid conclusion. In this type of project the student is working much like a scientist.

B. Technical Skill or Construction: In this type of project the student is doing some experimentation or work requiring mainly technical skill. He is not really investigating a problem, but he is using some of the processes of science or technology in his work.

C. Illustration or Demonstration: Here the student illustrates or demonstrates some scientific principle or process. Collections and models usually fall into this classification unless they show an unusual amount of technical skill in which case they would be classified in B above. Students attempt just to show something already known in this type of project.

Awards. OMSI (57, p. 3) recommends that at least the top ten percent of the projects in the local or school fair should receive the "Gold Medal Special Honors" certificate. An additional ten to thirty percent should receive "Silver Medal Special Honors" awards and the remainder of the students receive "Award of Merit certificates with a red seal for participating and completing a science project." Only
Gold Medal winners advance on through the county or regional fair, and eventually to the Northwest Science Fair.

In this study the award subgroups will be categorized as follows:

**Recognition:** A gold or silver award at any level is the highest award the student received.

**Participation:** A red award at any level is the highest award the student received.

**No Award:** The student participated in a class or school display but no awards were given.

**Teacher-School Motivation Factors.** Teacher-school motivation factors are those directions, requirements, encouragements, attitudes, and conveniences of time and facilities provided by the teacher and the school which may effect a student's participation in project making activities. The various teacher-school motivation factors are classified in Chapter IV.

**Student Motivation Factors.** Student motivation factors are those reasons given by the student as to why he made a project if at all. The various student motivation factors are classified in Chapter IV.

**Student Reactions.** The student reactions to project making
are those feelings that the student expresses as to his satisfaction in making the project in terms of an enjoyable activity and an activity from which he learns. The various student reactions are classified in Chapter IV.

Basic Assumptions

1. The SRA Primary Mental Abilities Test, Intermediate: Form AH, and the Otis Quick Scoring Mental Ability Test, Gamma: Form EM provide measures of the student's general mental ability (9, p. 496, 510).

2. The Sequential Tests of Educational Progress (STEP) Science Tests, Form: 3A and 2B accurately measure knowledge and understanding of science in both process and product criteria (23, p. 72).

3. The Occupational Interest Inventory, Intermediate Battery, 1956 Revision, accurately identifies "the broad field or fields of interest which appeal to the individual," and accurately measure "how much or how little interest one has in certain comprehensive occupational fields (10, p. 1)."

4. The student's responses to the Student Inventory reveals the student's participation in science project activities and presents feelings about interest in science as a
career choice.

5. The teacher's responses to the **Teacher Inventory** reveals the teacher's attitude and involvement with the stated objectives and method in project teaching.

6. The teacher's response to the **Student Rating Scale** reveals the teacher's evaluation of each student's achievement of both process and product criterion.

7. The individual classroom teachers administered each instrument fairly and correctly and followed given directions without bias in the conduct of the experiment.

**Procedures**

**Sample Selection**

In conference with Ray Barrett, the Educational Director of the Oregon Museum of Science and Industry and Bernice Tucker, Assistant Superintendent of the Multnomah County Intermediate Education District, it was determined that a sample of ninth grade students of the ninth grade classes of five schools in Multnomah County would provide a good stratified representation of schools which participate in Science Fair activities to varying degrees. The degrees of participation by the five schools are as follows:

- **School #1.** Had never held a Science Fair.
School #2. Held Science Fairs in the past but now holds a Departmental Display.

School #3. Active participant in Science Fairs.

School #4. Active participant in Science Fairs.

School #5. Has held Science Fairs in the past but will not hold one this year.

The five schools are located in four adjoining school districts of a suburban metropolitan area. The socioeconomic structure of this area has been largely equalized by the vast real estate developments of medium priced homes which characterizes the entire area.

All administrators and all of the teachers who were requested to participate in the study agreed to do so on the first request.

Sources of Data

Early in January, 1964, the ninth grade classes in the five participating schools were given a science process-product test and a science interest test. The teachers were asked to rate their students on a ten point scale of science knowledge and understanding of processes and to respond to a checklist concerning statements of objectives. The following instruments were administered at this time:

1. The Sequential Tests of Educational Progress (STEP) Science Test, Form 3A.
2. The Occupational Interest Inventory, Intermediate Battery, 1956 Revision.
3. The Teacher Inventory.
4. The Student Rating Scale.

The period of time between early January and late March is the interval in which intensive work on science projects is carried out (57, p. 18).

At the conclusion of the Northwest Science Fair in late March, a second testing was made of the same or equivalent forms of the process-products test and the interest test. The teachers were asked to rate their students a second time and students were asked to respond to a questionnaire concerning science project activities. The following instruments were administered at that time:

1. The STEP Science Test, Form 2B.
2. The Occupational Interest Inventory, Intermediate Battery, 1956 Revision.
3. The Student Inventory.
4. The Student Rating Scale.

The data were then organized and statistical tests were made to test the above hypotheses.

Administration and Scoring of the Instruments

Administration. In November and December of 1963, several
meetings were held with the seventeen participating teachers and all science department chairmen in the schools involved. A copy of the "Thesis Prospectus" was distributed to each and discussions were held as to the nature and purpose of the study, the teacher's role in the administration of the instruments and questions answered concerning various aspects of the study. During the first week of January, 1964 the first battery of tests and teacher rating scales were distributed with a set of written instructions for each teacher. After the administration this group of materials was collected. The administration of the second set in May, 1964 followed the same pattern.

**Scoring.** The various instruments were both hand and machine scored. Those which were hand scored were scored twice by independent scorers. The machine scoring was done by the Multnomah County Schools Superintendent's Office and by the Research Department of Portland Public Schools.

**Analysis of the Data**

The data were tabulated on data sheets and double checked for accuracy. A McBee Key sort\(^1\) card was prepared for each student and all data relating to that student's participation in the study were transferred to the card.

---

\(^1\) Royal McBee Corporation Ogden, Utah.
Appropriate statistical tests and appropriate tables were then prepared in order to interpret the data and to test the hypotheses.

Delimitation of the Problem

The study has been delimited as follows:

1. The study was limited to a stratified sample of five schools in Multnomah County. The sample was considered by experts in Science Fair Programs and in the Multnomah County School System to be a stratified representation of schools who participate in science project activities to a varying degree.

2. Data were collected on all freshmen students in all ninth grade classes in the five schools.

3. Only those students who were in continuous legal residence from January, 1964 to May, 1964 were considered as participants in the study.
CHAPTER II

BACKGROUND AND RELATED LITERATURE

Literature in the areas of objectives, outcomes and interest in science has been extensive. There have been few significant studies relating to project methods and even fewer which have attempted to find relationships between objectives, outcomes and project methods. A number of publications have appeared on Science Fairs; however, for the most part these have been descriptive rather than analytical.

A review of the selected related literature is discussed in this chapter. The chapter is divided into four sections:

1. Objectives and outcomes.
2. Interest.
3. Award Programs and Science Fairs.
4. Project methods.

Objectives and Outcomes

Bloom (28, p. 386) has defined learning as a change in behavior. He states that the desired changes in behavior should be stated in terms of objectives as determiners for the selection of effective teaching methods and for the selection of revealing
The importance of science objectives by national leaders in education becomes apparent on examination of the literature.

Richardson (58, p. 7) has divided the history of science teaching in the United States into three general periods, each characterized by predominant kinds of objectives:

- 1751-1872 Practical and expository
- 1872-1900 College preparatory
- 1900-present Evolution from college preparatory to functional

Hurd (39, p. 212) has summarized the science education objectives of secondary school teachers found in 1,373 articles published from 1901-1951. His analysis revealed trends towards:

1. Training students in the scientific method of thinking.
2. Developing certain scientific attitudes within the student.
3. Developing an appreciation of the contributions of science to society.
4. Aiding the student to discover a vocational interest.

The trends defined by Hurd are evident in recent and contemporary literature. In 1944 the Educational Policies Commission of the National Education Association published the report, *Education for All American Youth* (21, p. 133). The report established certain science objectives as desirable achievements for all children as follows:
1. An educated person will understand that science is based upon methods which man must slowly and painstakingly develop for discovering, verifying, interpreting, and organizing the facts of the world in which we live and about the people in it.

2. He will know that the use of scientific methods has made revolutionary changes in man's way of living and thinking.

3. He will see that the methods of science are one of mankind's chief instruments for making further progress.

4. He will know that scientific advances have depended upon precise measurement and active calculations; that mathematics is indispensable to scientific inquiry.

5. He will recognize that problems in human society as well as in the physical world should be attacked by scientific methods and a scientific point of view.

6. He will be familiar with certain fundamental principles and facts from the sciences, which when taken together, give him a sound view of the nature of the world in which he lives.

In 1946, the National Society for the Study of Education (53, p. 28) listed some types of objectives for science teaching as desirable directions for growth:

1. Functional information or facts.
2. Functional concepts.
3. Functional understanding of principles.
4. Instrumental skills.
5. Problem solving skills.
6. Attitudes.
7. Appreciations.
8. Interests.

In 1957, as an extension of the trend toward functional
objectives, Richardson (58, p. 8) "Hypothesized that the science teacher should teach in such ways that students will:

1. Develop the ability to think critically, to use the method of science effectively.

2. Acquire the principles, concepts, facts, and appreciations through which they can better understand and appreciate the nature of the earth, its inhabitants, and the universe.

3. Use wisely and effectively the natural resources of our earth as well as the products of science and technology.

4. Understand the social function of science and think and act in relation to the implications of science and technology for society.

5. Develop understandings that will contribute positively to their physical and mental health and their recreational interest.

6. Acquire information, understandings, and appreciations that will contribute to their educational and vocational guidance.

In 1959, the National Society for the study of Education devoted a third yearbook to science education. Hurd (52, p. 33) summarized the thinking of the times as follows:

The objectives of science-teaching as they appear in educational literature have changed little in the past twenty-five years. On the other hand, there have been changes in the nature of the science taught; for example, the sciences have become more unified and have gained an important position in world affairs. These factors suggest the need to re-think the purposes of teaching science in schools.

The following areas were suggested as a model from which
the "teacher may orient his thinking in developing his own purposes for teaching science (52, p. 34)."

1. Understanding Science.
2. Problem-Solving.
3. The Social Aspects of Science.
4. Appreciations.
5. Attitudes.
6. Careers.
7. Abilities.

The **Evaluative Criteria**, a widely used instrument in secondary school evaluations, appeared in 1960 and listed the following as guidelines in science teaching (54, p. 209):

1. The importance of major scientific principles and their discovery, understanding, and application.
2. The development of competence in the use of the methods of science.
3. The development of desirable attitudes, interests, and appreciations related to science and its applications.
4. The recognition of, and preparation for, the role of science in the evolving atomic and space age.

**Summary**

Learning is a change in behavior. In teaching, desired changes in behavior are stated in terms of objectives. In science teaching, the most acceptable contemporary statements of objectives are functional in nature.

The objectives as stated by leaders in science education may
be summarized as follows:

1. Students will develop an understanding of and skills in the scientific method.

2. Students will develop certain attitudes, and appreciations of the nature of science and the contributions of science to society.

3. Students will learn certain basic facts and principles and will develop certain basic skills.

4. Students will develop understandings of science as a vocation and will be aided in developing an interest in science as a vocation.

Interest

Loss and waste of manpower is a serious educational problem. Freeman (26, p. 191) states that less than 50 percent of the top 10 percent in intelligence enter college. Less than 43 percent of the top 10 percent finish college. Identification, guidance, motivation, improved instruction and scholarships are needed, according to Freeman, to utilize better our intellectual resources.

Ginsberg (30, p. 92) states that native endowment is not enough; training and development, among other things, are equally important to bring a greater number of gifted young people into scientific careers.
Witty (77, p. 312) states that "because of...lack of challenge, in their classroom, many gifted children lose interest in school and fail to develop in accord with their promise. ...gifted children who develop most effectively are those whose ability is recognized early and who are encouraged...."

Terman and his co-workers (70, p. 205) made an intensive longitudinal study of gifted children. Their subjects were children with an I.Q. of 135 or over (on the Stanford-Binet Scale), the highest one percent of children. In the sample were 115 boys and 100 girls. Among the findings that relate to the present study was the discovery that in Terman's sample the gifted children made collections twice as frequently as normal children. Such collections tended to be larger and more often of a scientific nature than in the case of average children. Avocational interests among the children in Terman's study, in order of frequency, were: sports, photography, music, gardening, reading-study, collections, woodworking and writing.

In a follow-up study, Terman (68, p. 25) analyzed the male scientists of his sample. He contrasted physical scientists, engineers, biologists, medical and college science majors with lawyers, humanities majors, and social science majors. Terman found that at an average age of 11, those who in later life entered the four groups of science occupations showed a far higher aptitude in science than did members of the non-science groups. Science aptitude was
identified at that age, usually by parents, teachers, or the children themselves. Terman found great stability of science interest from age 11 to age 30; the scientists in middle life ranked low in non-science-business interests; conversely, the non-science groups had low interest in science. He remarks: "Differences in interests are symptomatic of underlying differences in personality (68, p. 28)."

In another place Terman states that a science career could be predicted for 50 to 60 percent of children who actually became physical scientists, but only for 10 to 25 percent for the future social scientists, lawyers, and humanities specialists (69, p. 9). And again, "...early ability or interest in science is far more common among children who later become physical scientists, engineers, or biologists, than among those who later enter nonscientific fields (69, p. 36)."

Subarsky (66, p. 377) addressed himself to the question of the nature of science talent. "A fundamental ingredient of science talent is a high degree of innate curiosity," was his conclusion. This curiosity may ripen to an enduring interest which leads to a science career. Ability to recognize inconsistencies, contradictions, and problems, a creative imagination and qualitative thinking, mechanical-mindedness, and manual dexterity all contribute to science talent.

Finkel (24, p. 45) discovered that one-third of 594 high school
seniors were interested in a science career in elementary school but changed their minds later. Thus the problem is not how to interest children in science, but how to keep their native interest in this area alive.

Mallinson and Van Dragt (48, p. 362) found that only in 52 percent of the cases first ranking interest (not specifically science interest) in the ninth grade was still the area of highest interest in the twelfth grade, and the area of second highest interest remained second highest in only 34 percent of cases. A change in science and mathematics interest occurs often between the ninth and twelfth grade. They found substantial shift in ranking of interest, although when interest was very high in the ninth grade it usually remained almost as high in the twelfth grade. They concluded that interest as an indicator of talent and stability of first-ranking interest is dubious (48, p. 367).

A study by Super (67, p. 406) indicates the validity of studying vocational interest in early adolescence. He studied changes in interest of adolescence and concluded:

Interest patterns begin to crystallize by early adolescence, and the exploratory experiences of the adolescent years in most cases merely clarify and elaborate upon what has already begun to take shape. Some persons experience significant changes during adolescence and early adulthood, but these are most often related to endocrine changes, and less often to changes in the self-concept resulting from having attempted to live up to a misidentification
and to fit into an inappropriate pattern. Vocational interest patterns generally have a substantial degree of permanence at this stage: for most persons, adolescent exploration is an awakening to something that is already there.

These conclusions were reinforced by data from Bordin and Wilson (5, p. 297) which showed considerably more stability than instability of interests. With one year interval they found high interest test-retest reliabilities among groups of varying degrees of educational stability.

Daniels (16, p. 82) found that 28 percent of the former National Science Fair exhibitors had made their career choices by the time they were ready for high school and 65 percent had made their choices before high school graduation. Men and women were remarkably stable in their career choices; approximately one-half of both sexes carried out career plans made in high school.

In still another study, Zim (79, p. 344) investigated 69 young undergraduate scientists in college. He found that the average age when these youthful scientists became interested in science was at 10.5 years, and that more than 90 percent stayed in the area of their youth-time science interest. Therefore, he concluded the junior high school and elementary school should stimulate science interest for the sake of future science manpower needs.

Science interest can usually be recognized in the junior high school. "Since interest in science first develops at the elementary
and junior high school level, contests held late in the secondary school do not discover science talent. To a very small group of pupils with very unusual talent, they offer an opportunity for reward," according to Zim (78, p. 164).

The T. C. Howe High School of Indianapolis, Indiana, which Klinge (42, p. 67) investigated, offers special science classes on a volunteer basis for gifted children. These classes provide individual projects as a means of identifying science oriented attitudes and interests. The program has resulted in Westinghouse Science Talent Search awards and Bausch and Lomb scholarships, and has served as a feeder for science fairs.

**Summary**

Although the evidence at times is conflicting, the bulk of evidence seems to indicate that valid measures of students' vocational interest can be obtained as early as the ninth grade. These measures have a high degree of reliability thus indicating that this early age is an ideal time to stimulate science interest for the sake of future science manpower needs.

**Award Programs and Science Fairs**

The National Society for the Study of Education (53, p. 225) recommended, as far back as 1946, that superior high school
students need science clubs, junior science academies, awards, and recognition, and stated that not enough attention is paid to science-gifted youth.

Currently over 50 science incentive programs are sponsored in the United States by private and public organizations (14, p. 106). These competitions are generally recognized to be one of the many incentives which develop potential high caliber science manpower. The leading, nationwide science searches include the National Science Fair, Science Talent Search, Science Achievement Awards, and the Bausch and Lomb scholarship competitions. They vary among each other in scope and method.

The Science Achievement Awards are made annually. They are sponsored by the American Society for Metals and conducted by the Future Scientists of American Foundation of the National Science Teachers Association. This program has operated since 1952, and has distributed $5,000 in prizes equally to eight geographic regions. Contestants are drawn from grades 7 through 12. Tests are not given, and only written reports, photographs, and drawings are demanded of competitors (12, p. 193).

The Bausch and Lomb Optical Company gives annually an honorary science award to the most outstanding science student of each graduating high school class. Since 1944, the same company gives annually scholarships which carry a stipend of up to $1,500 to
three or more students. Selection is based on the high school record of the student and other qualifications, and involves 30 finalists who are interviewed on the University of Rochester campus during a three-day, all-expense paid trip (16, p. 36).

The Merit Scholarship Corporation was established in 1955. For the year 1958, over one-quarter of a million seniors, (one-sixth of the national senior class), from 13,000 high schools were expected to compete. In 1957, 1,392 awards were made. The competition consists of successive hurdles. Through progressive elimination 7,500 students become finalists. Each state of the Union is allotted a number of finalists which is pro-rated according to student population of the state's high schools. Stipends are given according to need, ranging from $100 to $2,200 per year, with an average of $650. Holland and Stalnaker (35, p. 9) made some follow-up studies on the Certificate of Merit winners and Merit Scholars, and found that 60 percent of them took up science and engineering programs in college.

The National Science Talent Search is sponsored by the Westinghouse Educational Foundation and conducted by Science Service in Washington, D. C. Science Service is a nonprofit corporation, with trustees nominated by the National Academy of Sciences, the National Research Council, the AAAS, the E. W. Scripps Estate, and the journalistic profession. Established in 1921, it conducts a
press service for scientific matter and information, publishes books and magazines and numbers among its activities the science Clubs of America, the Science Talent Search, and the National Science Fair (61, p. 5). Their stated purpose is "discovering and developing talent in American youth (61, p. 5)." Since 1942 annual awards and scholarships have been made to 40 winners each year. Five of the 40 winners receive a scholarship ranging from $1,500 to $3,000, and the 35 awards are $250 each. The 640 winners up to the year 1958 included 148 women. All finalists have attended college, and more than 50 percent of those who had had time to do so have obtained Ph. D. degrees. Most of the Ph. D.'s were employed in industry and academic research. Part of the conditions of the scholarships and awards is they must be applied to science or engineering courses in institutions of higher education.

Contestants of Science Talent Searches are selected by elimination, through successive hurdles which consist of a science aptitude examination, the high school record, recommendation by their high school teacher, rating on a 1000-word essay, and finally, among the top 40, a personal interview and a social attitude test. The number of girl winners is in proportion to the number of girl contestants. A follow-up study of Edgerton, Britt, and Norman (20, p. 403) in which winners and non-winners were studied, revealed
that the selection on the basis of the hurdles apparently was valid.

Science fairs had their beginning in this country in 1828 when the American Institute of the City of New York started the annual Industrial Fair. As an outgrowth of the Industrial Fair one hundred years earlier, the American Institute Children's Fair was conducted in 1928. Science clubs became popular in the 1940's and in 1958, 425,000 juniors and seniors in high school were members of 17,000 science clubs. National Science Fairs have been held since 1950, when 13 area fairs affiliated with the National Fair and sent 30 finalists to the competition in Philadelphia. In nine years the institution has grown so that 146 area fairs sent 281 finalists to the National Science Fair at Flint, Michigan in 1958 (3, p. 18).

The judging among exhibitors involves principally the science display of the student, which is rated on a point system, including creative ability (30 points), scientific thought (30 points), thoroughness (10 points), skill (10 points), and dramatic value (10 points). Jurors are usually college professors and scientists from various industries. Interviews of the exhibitors by the judges are recommended. Each finalist receives a gold or silver medal. On the basis of critical judging, some of the finalists receive "Wish Awards" (93 such awards worth $3,500 in 1958) consisting of scientific equipment and materials which the respective winners desired to carry on further experiments or research (61, p. 14).
Local schools that hold Science Fairs send their top exhibitors to city-wide area, or regional fairs. The top winners of regional or state fairs (sophomores, juniors, or seniors in high school) become the finalists who exhibit in the National Science Fair. The 1958 National Science Fair represented the top ranking competitors of a total of 400,000 science exhibits, the average National Science Fair finalist represented 1,668 exhibitors. Not more than two finalists, usually one boy and one girl, are selected from each area or state fair. The area or state fairs are sponsored by scientific and technical societies, civic and social groups, newspapers, or industry. An all-expense paid four-day program of scientific sightseeing and exhibition is provided at National Science Fairs for all finalists. Preliminary follow-up studies have shown that 88 percent of the finalists enter college seeking science or engineering careers. Seventy-one percent of the finalists from 1950 through 1955 responded to the inquiries conducted by Science Service (61, p. 8).

Beck (3, p. 150) classified the typical distribution of science fields in a National Science Fair, which was: 80 in physical sciences, 17 in chemistry, 15 in engineering, 7 in mathematics, 41 in biology, 69 in general science, 20 in physiography, and 15 in conservation.

Neivert (55, p. 19) noted that science competition winners tended to be concentrated in certain schools. She explained that
special intelligence of the student body could not account for this; rather, the better schools, and particularly the teachers' personality and educational skill, inspired the students with science potential. Frequently, when one particular science teacher left the school, the number of science award winning students decreased. However, the school to which this teacher went (which had not produced science winners before) now commenced to develop winners.

Daniels (16, p. 74) found that 58 percent of his respondents said that teachers had the greatest influence on their choice of careers.

Various authors have commented on the value of science fairs. Brown and Johnson state (7, p. 15): "Teachers report that science and mathematics fairs have encouraged many students to develop talents in science and mathematics."

Jones (40, p. 165) states that Science Fairs focus attention of the community on science, encourage and inspire youth, recognize talent without exploiting it, and encourage further work in science in college and industry.

Daniels (16, p. 101) found that at the National Science Fair level:

Almost 60 percent of both men and women stated that they were influenced in their occupational choice by Science Fair activities. The largest proportion of both sexes indicated a "mild" influence. While more than half of the Science Fair exhibitors could explicitly
acknowledge the positive influence their Science Fair activities exerted upon their choice of career, others probably experienced increased awareness of science career possibilities through their participation.

Daniels (16, p. 105) further qualified his study and pointed to future studies:

The present study dealt with contestants who had won state or regional awards and had then gone on to the national competition. All of these students were, in a sense, successful contestants, inasmuch as they received awards at least at the local level. This study, however, obviously did not involve the large numbers of students who did not win awards at the local level. It throws no light upon the attitudes which non-successful contestants in state and regional fields may have developed. It does point the way, however, for potential studies of such groups.

Warnings about possible adverse influences of Science Fairs have been sounded from several sources. Shreve (63, p. 334) acknowledges that the phenomenal growth of the Science Fair movement has been a stimulus for developing interest and popularizing science, but, a "desire for recognition has become so great that more attention is given to presentation of the project than to the research and development of it." And he speaks of "product at the expense of process (63, p. 334)." He suggests that more industrial arts than understanding of scientific principles may result. Oral presentation of the projects to the judges tends to diminish this danger, but often the presentation seems rehearsed, which would be unfair and a waste of time. Showmanship and the desire to win
can endanger the whole program.

Simmons says that students with high I.Q. and recognized science capacities: "...fell apart when it came to stiff competition (64, p. 225)." He asks whether the projects can scare potential scientists out of a science career, whether the projects can lead the industrial arts and art students into false science hopes, and whether teachers become "producers" instead of resource persons?

Kraus (43, p. 335), too, sees a danger in too much outside help in producing Science Fair projects, and in economic discrimination in the accessibility of exhibit materials. Another danger he points to is a concentration on "popular" science.

MacCurdy and Bagshaw (47, p. 226) made a study of the judgments of 21 judges who had judged a large local Science Fair. With the inconsistencies among the judges scores, "It was apparent that the winners had been established by a method that was open to serious criticism." It was observed that the judgments had neither reliability nor validity.

Summary

Currently a large number of science incentive programs are sponsored in the United States by private and public organizations. These competitions are generally recognized to be one of the many incentives which develop potential high caliber science manpower.
The awards are most frequently in the form of recognition, scholarships, and funds to continue further investigations.

The evaluation of these programs has been largely descriptive with few analytical studies at any level particularly the local level.

Statements of values and warnings of adverse influence indicate many areas where more definitive studies need to be done.

**Project Method**

Research evidence on the effectiveness of the project method, "though meager, is not particularly favorable (28, p. 483)." The project method is characterized by the acceptance of an assignment by the student, who is then free to fulfill the requirements independently, with help from the teacher when necessary (28, p. 483).

Harris (34, p. 852) indicates that the project method has past its prime:

The project and activity methods were commonly used in the literature of educational method in the twenties and thirties, but are used much less at the present time. No common definitions of the terms ever developed, and consequently many varying types of practice went on under the same name.

Harris (34, p. 852) reported on two studies which were favorable to the project method but he indicates that the studies were of dubious validity.

Richardson (58, p. 83) reported that the National Science
Teachers Association defined a project as "simply a study of something -- what it is and how it happened, is happening, or might be made to happen."

Richardson (58, p. 83) advocated the use of student projects as "an excellent opportunity for the complete act of thinking by the student." He further advised that "generally the project involves some physical outcome -- a product, display, or perhaps a written report."

Burnett (8, p. 338) reported on a successful teacher who uses the individual project method as the chief or only teaching-learning procedure employed. However, Burnett (8, p. 337) made the following note of caution on such an approach:

Unfortunately, we have little substantial data with which to assess the soundness of this procedure in achieving the goals of science teaching.

**Summary**

The project method, though still advocated by leaders in science education, is ill-defined and untested by valid studies. The most acceptable current definition of the project method involves the acceptance of an assignment by the student, who is then free to fulfill the requirements independently, with help from the teacher when necessary.
CHAPTER III

DESIGN OF THE STUDY

This chapter will contain the procedures used to select the participating schools and the instruments utilized in collecting the data. The rationale for the experimental design and the statistical procedures will be presented.

This chapter will be divided into four sections:

1. Sample Selection
2. Experimental Design
3. Statistical Tests
4. Instrument Selection

Sample Selection

In conference with Ray Barrett, the Educational Director of the Oregon Museum of Science and Industry, and Bernice Tucker, Assistant Superintendent of the Multnomah County Intermediate Education District, the schools of Multnomah County were examined for possible laboratory schools in which to conduct this study. The schools were examined for history and degree of participation in Science Fair activities, socioeconomic status of the school community, and levels of educational achievement.
Five schools were selected which, according to County records, had similar levels of educational achievement. The five schools are located in four adjoining school districts of a suburban metropolitan area. The socioeconomic structure of this area has been largely equalized by the vast real estate development of medium priced homes which characterizes the entire area.

It was determined that a sample of ninth grade students of the ninth grade classes of five schools in East Multnomah County would provide a good stratified representation of schools which participate in Science Fair activities to varying degrees. It was assumed that the varying degrees of participation in Science Fair activities would produce equally varying uses of science projects as a teaching method. The degrees of participation and enrollments in the ninth grade science classes are shown in Table I.

All administrators and all of the teachers who were requested to participate in the study agreed to do so on the first request.

Only freshman science students who were in continuous legal residence from January, 1964 to May, 1964 were considered as participants in the study. In some of the schools, students are not required to elect a science subject during the Freshman year and may then take the Freshman science class as a Sophomore. After identifying and eliminating Sophomore students and those students who were not in continuous legal residence, the final sample numbered 952.
Table I. Degree of participation in Science Fair activities and enrollments for the ninth grade science classes in the sample schools during 1963.

<table>
<thead>
<tr>
<th>School</th>
<th>Participation</th>
<th>No. of Teachers</th>
<th>No. of Classes</th>
<th>No. of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Has never held a Science Fair</td>
<td>6</td>
<td>20</td>
<td>516</td>
</tr>
<tr>
<td>B</td>
<td>Held Science Fairs in the past, now hold departmental displays</td>
<td>5</td>
<td>17</td>
<td>430</td>
</tr>
<tr>
<td>C</td>
<td>Active participants in Science Fairs</td>
<td>1</td>
<td>5</td>
<td>105</td>
</tr>
<tr>
<td>D</td>
<td>Active participant in Science Fairs</td>
<td>2</td>
<td>12</td>
<td>323</td>
</tr>
<tr>
<td>E</td>
<td>Has held Science Fairs in past, no Fair or display this year</td>
<td>3</td>
<td>7</td>
<td>213</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>17</td>
<td>61</td>
<td>1,587</td>
</tr>
</tbody>
</table>

**Experimental Design**

The chosen design was experimental insofar as variables are identified and their effects upon other variables observed. It is not a design "in the Fisher tradition in which an experimenter having complete mastery can schedule treatments and measurements for optimal statistical efficiency (28, p. 171)." Those departures from a true experimental design will be noted in this chapter and then
Because of the nature of the study, the "Non-equivalent Control Group Design" was chosen as the design for the study. This quasi-experimental design has been described by Campbell and Stanley (28, p. 217).

One of the most widespread experimental designs in educational research involves an experimental group and a control group both given a pretest and a post-test, but in which the control group and the experimental group do not have pre-experimental sampling equivalence. Rather the groups constitute naturally assembled collectives such as classrooms, as similar as availability permits but not yet so similar that one can dispense with the pretest. The assignment of X to one group or the other is assumed to be random and under the experimenter's control.

The design may be represented as follows where the O's are the observations and the X is the treatment (28, p. 218):

```
     O X O
     -------------
     O      O
```

Campbell and Stanley (28, p. 218) have noted the conditions which effect the validity of this design.

The more similar the experimental and the control groups are in their recruitment, and the more this similarity is confirmed by the scores on the pretest, the more effective this control becomes. Assuming that these desiderata are approximated for purposes of internal validity, we can regard the design as controlling the main effects of history, maturation, testing and instrumentation, in that the difference for the experimental
group between pretest and post-test (if greater than that for the control group) cannot be explained by main effects of these variables such as would be found affecting both the experimental and the control group.

The assignment of the treatment to one group or the other is assumed to be random and under the experimenter's control; however, ...there are instances when the respondents are clearly self-selected, the experimental group having clearly sought out exposure to X, with no control group available from this same population of seekers. In this (later) case, the assumption of uniform regression between experimental and control groups becomes less likely and selection maturation interaction (and other selection interactions) become more probable. The "self-selected" (design) is thus much weaker, but it does provide information which in many instances would rule out the hypothesis that X has an effect. The control group, even if widely divergent in method of recruitment and in mean level, assists in the interpretation (28, p. 220).

Regression effects as an internal validity problem has been reduced by avoidance of matching and no selection on the basis of extreme scores on the criterion or correlated measures (28, p. 219).

The caution on the selection interaction threat to internal validity is noted and will be utilized in the interpretation of the data.

To minimize the effect of the uncertainty in pre-experimental equivalence, the analysis of covariance was chosen for testing the effects of the experimental variable with the pretest and I.Q. scores
used as the covariate (28, p. 219).

Random sampling within various stratified subgroups in the total sample was selected as the sampling method as recommended by Wert (76, p. 108).

John Best (4, p. 205) notes that when taking a random sample from a group composed of distinct subgroups that a pure random sample may be unduly weighted in favor of one of the subgroups.

Wallis and Roberts (75, p. 118) support the position that when expert judgment deems that the population is indeed made up of strata that stratifying the populating on expert judgment is not incompatible with randomization.

Statistical Tests

It was desirable to avoid the procedure of matching and the selecting of extreme scores in order to minimize regression effects as an internal validity problem. Several investigators have called attention to the use of the analysis of covariance for testing the effects of the experimental variable without the procedure of matching. "Simple gain scores are also applicable but usually less desirable than analysis of covariance (28, p. 219)."

The analysis of covariance provides tests of significance for the comparison of groups whose members may have been stratified and whose members have been measured with regard to one or more
variable characteristics other than the criterion (76, p. 343).

The conditions under which one may safely conclude from a significant F that the experimental treatment have different effects have been listed by Lindquist (46, p. 323) as follows:

1. The subjects in each treatment group were originally drawn either (a) at random from the same parent population, or (b) selected from the same parent population on the basis of their X-measures only--the selection being random with reference to all other factors for any given value of X.

2. The X-measures are unaffected by the treatments.

3. The criterion measures for each treatment group are a random sample from those for a corresponding treatment population.

4. The regression of Y on X is the same for all treatment populations.

5. This regression is linear.

6. The distribution of adjusted scores for each treatment population is normal.

7. These distributions have the same variance.

8. The mean of the adjusted scores is the same for all treatment populations.

The method of self-selection of the treatment groups has already been noted with due cautions and justifications for continuance of the study (28, p. 220).

The X-measures (pretests) are unaffected by the treatment because they were obtained before the administration of the treatments (46, p. 323).
Condition three is contained in condition one (46, p. 325).

Regression effects, as noted, have been reduced by avoidance of matching and no selection on the basis of extreme scores on the criterion or correlated measures (28, p. 219).

Assumptions concerning linearity of regression, normality of distribution, and homogeneity of variance "must generally represent judgments based on a priori considerations --since available statistical tests of the validity of these assumptions are both low in power and difficult to apply (46, p. 330)." 

Condition eight is contained in the null-hypothesis.

Wert (76, p. 183) has commented on the limits of tolerance within these conditions.

The more the data in an investigation depart from the strict fulfillment of the assumptions the more likely is the investigator to reach erroneous conclusions. In the actual research situation, particularly in the social sciences, it may be difficult to satisfy all assumptions. Further, it is doubtful whether this failure is sufficiently great in most situations to invalidate the application of the technique. Recent evidence suggests that the limits of tolerance within which the assumptions must be approximated are wider than it was originally thought.

Therefore, with due regard for the selection interaction threat to internal validity, all conditions for the use of the analysis of covariance have been reasonably met.
Selection of Instruments

Two recurring themes in the statement of science project objectives (57, p. 2) concern the process-product aspects of achievement in science and interest in science. The instruments chosen to measure the outcomes of these objectives are examined in the sections which follow.

The STEP Science Test

According to Horrocks (37, p. 459), "Achievement is a term used to indicate the status or level of a person's learning and his ability to apply what he has learned."

Dressel (19, p. 342) reported on a study undertaken by the Committee on Evaluation of the National Science Teachers Association. The committee made a survey of the standardized tests available for use in science classrooms.

It had two purposes in mind: (1) to study the weakness and strengths of existing tests, and (2) to determine the need for additional tests in particular areas so that the Committee members might recommend the writing and publication of such tests for wide distribution.

The Committee's first conclusion was that most available standardized tests in the science area are chiefly designed to measure achievement; the greater number of items attempt to measure a student's retention of specific facts rather than his ability to analyze a problem, propose hypotheses, and work out a solution.
If teachers teach for such objectives as understanding of science theories, the structure of science, problem solving, the ability to reason logically, and the ability to apply what is learned to new situations, most of the standardized tests are now available tell them little about the extent to which these objectives are being realized. Evaluation instruments for these objectives must be made by teachers themselves until such time as better standardized tests are available.

The **Sequential Tests of Educational Progress (STEP) Science Test** was being published at the time the study was being made and was not available to the Committee for examination. The authors of the **STEP Science Test** were attempting to overcome some of the objections of the kind raised by the Committee. According to the publisher, the intent was for STEP to "focuses on skill in solving new problems on the basis of information learned rather than on ability to handle only lesson material (22, p. 5)."

The manual (22, p. 5) describes the test as follows:

Measures ability to identify and define scientific problems, to suggest or eliminate hypotheses, to select procedures for testing hypotheses, to interpret data and draw conclusions, to evaluate critically statements by others, and to reason quantitatively and symbolically. Questions are included in biology, chemistry, physics, meteorology, astronomy, and geology; they emphasize applications of science in home, economic, cultural, and social situations.

The science test was developed by the joint effort of a committee of outstanding leaders and teachers in science from many sections of the country and of Educational Testing Service staff.
members who are both subject-matter and test-construction specialists (22, p. 6)."

The committee planning the test prepared a list of fundamental knowledge areas and reasoning abilities which they believed should be assessed. The lists along with the approximate percentage of questions designed to probe each of the subgroups listed are shown in Table II. A phase of one of the concepts that was considered appropriate for a particular grade level was selected and combined with one of the six abilities to be tested to form the basis for each item written for the test (22, p. 7).

Stanley (65, p. 148) examined the technical reports of the STEP Science Tests and concluded that the test "measures something besides intellectual ability as represented by the SCAT-V, SCAT-Q, and SCAT-T scores, and that this something is 'knowledge and understanding of general science.' It seems at least as likely as most other general-science tests to do this."

The reviews in Buros (9, p. 802) conclude that "the tests constitute a new approach to the construction of achievement tests. They are designed to measure how well students can make use of what they have learned in the classroom."

The Occupational Interest Inventory

Horrock's (37, p. 665) has defined interest as when:
Table II. List of fundamental knowledge areas and reasoning abilities prepared by the test-construction committee for the Step Science Test (23, p. 7).

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Percentage of Questions in Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasoning Abilities</td>
<td></td>
</tr>
<tr>
<td>1. Ability to identify and define scientific problems.</td>
<td>10%</td>
</tr>
<tr>
<td>2. Ability to suggest or screen hypotheses.</td>
<td>25%</td>
</tr>
<tr>
<td>3. Ability to select valid procedures.</td>
<td>17%</td>
</tr>
<tr>
<td>4. Ability to interpret data and draw conclusions.</td>
<td>23%</td>
</tr>
<tr>
<td>5. Ability to evaluate critically claims or statements.</td>
<td>12%</td>
</tr>
<tr>
<td>6. Ability to reason quantitatively and symbolically.</td>
<td>13%</td>
</tr>
<tr>
<td>Subtotal</td>
<td>100%</td>
</tr>
<tr>
<td>Scientific Knowledge</td>
<td></td>
</tr>
<tr>
<td>1. Biology</td>
<td>40%</td>
</tr>
<tr>
<td>2. Chemistry</td>
<td>16%</td>
</tr>
<tr>
<td>3. Physics</td>
<td>23%</td>
</tr>
<tr>
<td>4. Astronomy</td>
<td>8%</td>
</tr>
<tr>
<td>5. Geology</td>
<td>7%</td>
</tr>
<tr>
<td>6. Meteorology</td>
<td>6%</td>
</tr>
<tr>
<td>Subtotal</td>
<td>100%</td>
</tr>
</tbody>
</table>
An individual is seen as interested in those aspects of his environment which give him pleasure and satisfaction, which offer a welcome challenge, or which compel and hold attention.

Traditionally published tests of interests have been pretty much confined to measures of vocational preference (37, p. 667).

The Occupational Interest Inventory is designed to measure occupational and vocational preference; it is not a test of abilities or skills. Its purpose is to identify the broad field or fields of interest for the individual (10, p. 1).

Persons interested in research, invention, and the explanation of natural phenomena earn high scores in the science area. The indicated responses are typical of scientists and most types of laboratory workers (10, p. 1).

The publishers indicate reliability coefficient of .87 for the science component. All other field components are .87 or higher (10, p. 5).

The Teacher Inventory

The Teacher Inventory was designed for this study primarily to assess the teacher's attitude towards the objectives of project making activities as proposed by OMSI (57, p. 2) and to assess the degree that the teacher and the school attempt to involve students in science project activities.
The methods choices and the activities descriptions were used to validate the teacher's perceptions of his involvement in teaching toward each objective and to validate the report of his students' involvement in project activities.

The Teacher Inventory was used to identify and classify the teacher-school motivation factors which might affect a student's participation in project making activities.

The Student Inventory

The Student Inventory was designed primarily to assess the students' involvement in project activities. From these data, the student motivation factors were identified and classified, the students' reactions to project activities were obtained, the project making record, type of project, awards received, and career choice were compiled.

It should be noted that the teacher-school motivation factors in some ways reflect teachers' attitudes. The student motivation factors and the students' reaction in some ways reflect students' attitudes. Howe (38, p. 205) found that "during the school year students developed more favorable attitudes toward science and scientific careers" and that "student attitudes tended to change in the direction of those held by their teacher."
The Teacher Inventory and the Student Inventory were used in cross-validating in an attempt to clarify both the teachers' and students' perceptions of their involvement in project activities.

The Student Rating Scale

The Student Rating Scale was designed to obtain the rating by the teacher of the students' science performance. The scale was divided into process and product items primarily to require the teacher to expend at least twice the thought on each student as otherwise might be expended.

The process and product ratings were combined, to form the student rating. This procedure of rating the student appears to follow more closely the procedures followed when the STEP Science Tests were constructed since each item in the test requires some use of process as well as knowledge (22, p. 7).

The mean and standard deviation of each teacher's ratings were obtained and converted to standard scores with mean 50 and standard deviation 10 for comparability (73, p. 103).

Tests of Intelligence

The investigator encountered the difficulty of having more than one intelligence test available for control purposes. The schools had previously given an intelligence test in the ninth grade and under
the County system had an option of two different tests, SRA Primary Mental Abilities and Otis Quick Scoring. Due to the nature of the heavy testing schedule under this study it was impossible to secure permission from any of the schools for the administration of a common intelligence test. Baron (1, p. 78) points out the dangers involved in comparing IQ's derived from different intelligence tests: however, both of the intelligence tests used in the various schools involved in the study are rated by Buros (9, p. 510, 496) as tests of general intelligence. The tests measure different aspects of intelligence; however, both are rated as tests of general intelligence and predictors of scholastic success.

A common attribute of standard scores according to Walker (73, p. 103) and Horrocks (37, p. 44) is that they are comparable. Baron (1, p. 63) lists the uses and advantages of standard scores as follows:

1. **Standard scores represent equal units of measurement and hence facilitate comparisons regardless of the area of the distribution of scores under consideration.**

2. **Standard scores from different tests are comparable to the extent that they may be averaged or combined (if the assumption of normality seems to be warranted).** This applies even though the tests may contain different numbers of items and one test may be more difficult than the other.

3. **Standard scores are based essentially on score points on the test rather than on rank order.** This facilitates interpretations in terms of ability or
achievement as represented by test score and indicates relative standing in the group at the same time.

4. Mathematically, standard scores have other values. The zero point is always the mean (standard score 50 as described here). The mean is the most stable measure of central tendency, that is, the most stable central score. The range between standard scores of 40 and 50 represents one standard deviation below the mean (or average). The standard deviation is the most reliable measure of variability within the group and has many statistical uses.

Walker (73, p. 103) gives an example of comparing three values on three different tests in reading, artificial language, and arithmetic stating that they are "directly comparable" when converted to standard scores.

If according to Buros the intelligence tests used by the schools in the study measure general intelligence then one could compare the tests on the basis of general intelligence by the use of standard scores. The tests were standardized at mean 100 and standard deviation 15.
CHAPTER IV

THE STUDY

This study was undertaken to determine the effects of science project making on the student's achievement, interest in science, and the teachers' ratings of project makers.

Early in January, 1964, the ninth grade classes in the five participating schools were given a science process-product test and a science interest test. The teachers were asked to rate their students on a ten point scale of science knowledge and understanding of processes and to respond to a checklist concerning statements of objectives and their involvement in project activities. The following instruments were administered at this time:

1. **The STEP Science Test, Form 3A.**
2. **The Occupational Interest Inventory, Intermediate Battery, 1956 Revision.**
3. **The Teacher Inventory.**
4. **The Student Rating Scale.**

The period of time between early January and late March is the interval in which intensive work on science projects is carried out (57, p. 18).

At the conclusion of the Northwest Science Fair in late March,
a second testing was made of the same or equivalent forms of the process-products test and the interest test. The teachers were asked to rate their students a second time and the students were asked to respond to a questionnaire concerning Science Fair and science project participation. The following instruments were administered at this time:

1. The STEP Science Test, Form 2B.
2. The Occupational Interest Inventory, Intermediate Battery, 1956 Revision.
3. The Student Inventory.
4. The Student Rating Scale.

The data were then organized and statistical tests were made to test the hypotheses. The null hypotheses have been stated in Chapter I and will be restated in this chapter when the tests of the hypotheses are made.

In order to determine the effects of science project making, certain criterion and control variables were considered. The criterion variables are those variables which the investigator wishes to assess the effect upon by certain treatments. In this study the criterion variables are as follows:

1. The student's achievement in science.
2. The student's interest in science.
3. The teacher's rating of the student.
The non-criterion or control variables are those variables which because of individual differences among the members of the sample are either known to influence the criterion or suspected of such influence (76, p. 343). In this study the non-criterion variables identified are as follows:

1. The student's achievement in science prior to the treatment.
2. The student's interest in science prior to the treatment.
3. The teacher's rating of the student prior to the treatment.
4. The student's basic intelligence.
5. The student's previous experience in project making.
6. The student's involvement in process through the type of project made.
7. The student's career choice.
8. Factors motivating the student to make a project.

The chapter will be divided into five parts.

1. Experience in Project Making.
3. Type of Project.
4. Motivation Factors: Awards
5. Motivation Factors.
Experience in Project Making

Sample Selection

Experience in project making was selected as the first control variable to study and was controlled through stratification (76, p. 343). The 952 students who participated in the study were grouped according to previous experience in project making as shown in Table III.

Two years experience in project making as opposed to no experience in project making represented the widest possible difference in experience from the data available in the study. To achieve stratification, the subgroups were constituted as follows:

1. The students with two years experience who made projects in the ninth grade.
2. The students with no experience who made projects in the ninth grade.
3. The students with two years experience who did not make projects in the ninth grade.
4. The students with no experience who did not make projects in the ninth grade.
Table III. Number of students making projects by grade level.

<table>
<thead>
<tr>
<th>Grade in Which Project Was Made</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>7, 8, 9</td>
<td>57</td>
</tr>
<tr>
<td>8, 9</td>
<td>87</td>
</tr>
<tr>
<td>7, 9</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>7, 8</td>
<td>190</td>
</tr>
<tr>
<td>8</td>
<td>177</td>
</tr>
<tr>
<td>7</td>
<td>63</td>
</tr>
<tr>
<td>None</td>
<td>309</td>
</tr>
<tr>
<td>Total</td>
<td>952</td>
</tr>
</tbody>
</table>

Samples of equal size were selected from each of the subgroups in order to avoid disproportionality (76, p. 103, 211). A random sample of 20 was selected from each subgroup for a total sample of 80.

Achievement

The null hypotheses one, two, and three as stated in Chapter I are restated here and the analysis of covariance multiple classification applied in order to test for significance (76, p. 352). Significant tests at both the one and five percent levels are reported.
Hypothesis 1. Students who made projects did not differ in achievement from students who did not make projects with pretest and IQ scores held constant.

Hypothesis 2. Students with previous project making experience did not differ in achievement from students without previous project making experience, with pretest and IQ scores held constant.

Hypothesis 3. Students who made projects did not differ in achievement from students who did not make projects whether they had previous experience in project making or did not have previous experience in project making, with pretest and IQ scores held constant.

A summary of the experimental data for the subgroups and the results of the analysis of covariance is reported in Table IV.

In order to be significant at the five percent level of confidence, an $F$-value with 1 and 74 degrees of freedom must be 3.97 (76, p. 422).

For the three hypotheses, $F$-values of 2.50, 0.56, and 0.13 respectively were obtained, and all three values are nonsignificant; therefore, the null hypotheses one, two, and three are accepted.
Table IV. Summary of experimental achievement data for ninth grade project groups stratified for experience in project making.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>$\bar{Y}^*$</th>
<th>$\bar{X}_1^*$</th>
<th>$\bar{X}_2^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td>20</td>
<td>23.95</td>
<td>108.60</td>
<td>39.05</td>
</tr>
<tr>
<td>No Experience</td>
<td>20</td>
<td>27.20</td>
<td>112.85</td>
<td>40.90</td>
</tr>
<tr>
<td>Subtotal</td>
<td>40</td>
<td>25.58</td>
<td>110.75</td>
<td>39.98</td>
</tr>
<tr>
<td>No Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td>20</td>
<td>32.45</td>
<td>114.30</td>
<td>45.90</td>
</tr>
<tr>
<td>No Experience</td>
<td>20</td>
<td>27.85</td>
<td>108.20</td>
<td>41.15</td>
</tr>
<tr>
<td>Subtotal</td>
<td>40</td>
<td>30.15</td>
<td>111.25</td>
<td>43.53</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>27.86</td>
<td>110.99</td>
<td>41.75</td>
</tr>
</tbody>
</table>

Sources of Residuals

<table>
<thead>
<tr>
<th>Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>$F_{1,74}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>83.64466</td>
<td>83.64466</td>
<td>2.50</td>
</tr>
<tr>
<td>Experience</td>
<td>1</td>
<td>18.60021</td>
<td>18.60021</td>
<td>0.56</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>4.25828</td>
<td>4.25828</td>
<td>0.13</td>
</tr>
<tr>
<td>Within</td>
<td>74</td>
<td>2478.96666</td>
<td>33.49955</td>
<td></td>
</tr>
</tbody>
</table>

*Y STEP 2B Post test
$\bar{X}_1$ IQ Scores
$\bar{X}_2$ STEP 3A Pretest
Interest

The null hypotheses four, five, and six as stated in Chapter I are restated here and the analysis of covariance multiple classification applied in order to test for significance (76, p. 352). Significant tests at both the one and five percent levels are reported.

Hypothesis 4. Students who made projects did not differ in science interest from students who did not make projects, with pretest and IQ scores held constant.

Hypothesis 5. Students with previous project making experience did not differ in science interest from students without previous project making experience, with pretest and IQ scores held constant.

Hypothesis 6. Students who made projects did not differ in science interest from students who did not make projects whether they had previous experience in project making or did not have previous experience in project making, with pretest and IQ scores held constant.

A summary of the experimental data for the subgroups and the results of the analysis of covariance is reported in Table V.
Table V. Summary of experimental interest data for ninth grade project groups stratified for experience in project making.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>( \overline{Y^*} )</th>
<th>( \overline{X_1^*} )</th>
<th>( \overline{X_2^*} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td>20</td>
<td>19.55</td>
<td>108.60</td>
<td>18.25</td>
</tr>
<tr>
<td>No Experience</td>
<td>20</td>
<td>19.25</td>
<td>112.85</td>
<td>18.10</td>
</tr>
<tr>
<td>Subtotal</td>
<td>40</td>
<td>19.40</td>
<td>110.75</td>
<td>18.18</td>
</tr>
<tr>
<td>No Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td>20</td>
<td>23.40</td>
<td>114.30</td>
<td>23.45</td>
</tr>
<tr>
<td>No Experience</td>
<td>20</td>
<td>19.55</td>
<td>108.20</td>
<td>20.20</td>
</tr>
<tr>
<td>Subtotal</td>
<td>40</td>
<td>21.48</td>
<td>111.25</td>
<td>21.83</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>20.44</td>
<td>110.99</td>
<td>20.20</td>
</tr>
</tbody>
</table>

Sources of Variation

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>( F_{1,74} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>7.18455</td>
<td>7.18455</td>
<td>0.38</td>
</tr>
<tr>
<td>Experience</td>
<td>1</td>
<td>10.50288</td>
<td>10.50288</td>
<td>0.56 n. s.</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>6.95205</td>
<td>6.95205</td>
<td>0.37 n. s.</td>
</tr>
<tr>
<td>Within</td>
<td>74</td>
<td>1383.15489</td>
<td>18.69113</td>
<td>0.37 n. s.</td>
</tr>
</tbody>
</table>

\( \overline{Y^*} \) Occupational Interest Inventory Post-test

\( \overline{X_1^*} \) IQ Scores

\( \overline{X_2^*} \) Occupational Interest Inventory Pretest
In order to be significant at the five percent level of confidence, an F-value with 1 and 74 degrees of freedom must be 3.97 (76, p. 422). For the three hypotheses, F-values of 0.38, 0.56, and 0.37 respectively were obtained and all three values are non-significant; therefore, the null hypotheses four, five, and six are accepted.

**Career Choice**

**Sample Selection**

The student's career choice was chosen as the second control variable to examine and was controlled through stratification (76, p. 343). A unique situation developed which enabled the investigator to control seven out of the eight non-criterion factors simultaneously.

One teacher, (X), had an interesting division in his classes between students who made ninth grade projects and students who did not make projects as shown in Table VI.

Limiting the sample to one teacher enables one to control the motivational factors which might be attributed to the teacher and the school. By choosing the subclasses in which the students made projects in the ninth grade only and in which the students had never made projects enables one to control the experience variable.
Table VI. Subclasses for teacher (X) according to grade in which project was made and science career choice.

<table>
<thead>
<tr>
<th>Grade in Which Project was Made</th>
<th>Number of Students</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>k</td>
<td>Science Career</td>
<td>No Science Career</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------</td>
<td>---</td>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>7, 8, 9</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8, 9</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7, 9</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>10</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>7, 8</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>19</td>
<td>3</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>40</td>
<td>14</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>117</td>
<td>36</td>
<td>81</td>
<td></td>
</tr>
</tbody>
</table>

Stratification by career choice enables one to control career orientation effects on the criterion. Achievement, basic intelligence, interest, and teacher ratings prior to the treatment are controlled through the use of the analysis of covariance (76, p. 343).

To achieve stratification, the subgroups were constituted as follows:

1. The students who chose science as a career and who made projects in the ninth grade.

2. The students who did not choose science as a career and
who made projects in the ninth grade.

3. The students who chose science as a career and who did not make projects in the ninth grade.

4. The students who did not choose science as a career and who did not make projects in the ninth grade.

Samples of equal size were selected from each of the subgroups in order to avoid disproportionality (76, p. 103, 211). A random sample of 10 was selected from each subgroup for a total sample of 40.

Achievement

The null hypotheses seven, eight, and nine as stated in Chapter I are restated here and the analysis of covariance multiple classification applied in order to test for significance (76, p. 352). Significant tests at both the one and five percent levels are reported.

Hypothesis 7. Students who made projects did not differ in achievement from students who did not make projects, with pretest, IQ scores, experience, teacher, and school held constant.

Hypothesis 8. Students who chose science careers did not differ in achievement from students who did not choose science careers, with pretest, IQ
scores, experience, teacher, and school held constant.

Hypothesis 9. Students who made projects did not differ in achievement from students who did not make projects whether they chose science careers or did not choose science careers, with pre-test, IQ scores, experience, teacher, and school held constant.

A summary of the experimental data for the subgroups and the results of the analysis of covariance is reported in Table VII.

In order to be significant at the five percent level of confidence an F-value with 1 and 34 degrees of freedom must be 4.13 (76, p. 421). For the three hypotheses, F-values of 0.96, 2.37, and 2.03 respectively were obtained and all three are nonsignificant; therefore, the null hypotheses seven, eight, and nine are accepted.

Interest

The null hypotheses 10, 11, and 12 as stated in Chapter I are restated here and the analysis of covariance multiple classification applied in order to test for significance (76, p. 352). Significant tests at both the one and five percent levels are reported.

Hypothesis 10. Students who made projects did not differ in science interest from students who did not
Table VII. Summary of experimental achievement data for ninth grade project groups stratified for career choice.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>Y*</th>
<th>X*1</th>
<th>X*2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>33.10</td>
<td>119.80</td>
<td>44.50</td>
</tr>
<tr>
<td>No Science Career</td>
<td>10</td>
<td>31.50</td>
<td>123.60</td>
<td>47.50</td>
</tr>
<tr>
<td>Subtotal</td>
<td>20</td>
<td>32.30</td>
<td>121.70</td>
<td>46.00</td>
</tr>
<tr>
<td>No Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>33.80</td>
<td>114.60</td>
<td>45.00</td>
</tr>
<tr>
<td>No Science Career</td>
<td>10</td>
<td>27.10</td>
<td>111.10</td>
<td>36.70</td>
</tr>
<tr>
<td>Subtotal</td>
<td>20</td>
<td>30.45</td>
<td>112.85</td>
<td>40.85</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>31.38</td>
<td>117.28</td>
<td>43.43</td>
</tr>
</tbody>
</table>

Source of Residuals

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F 1, 34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>26.27675</td>
<td>26.27675</td>
<td>0.96</td>
</tr>
<tr>
<td>Career</td>
<td>1</td>
<td>65.33261</td>
<td>65.33261</td>
<td>2.37</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>55.78576</td>
<td>55.78576</td>
<td>2.03</td>
</tr>
<tr>
<td>Within</td>
<td>34</td>
<td>935.84559</td>
<td>27.52487</td>
<td></td>
</tr>
</tbody>
</table>

*Y STEP 2B Post-test

X*1 IQ Scores

X*2 STEP 3A Pretest
make projects with pretest, IQ scores, experience, teacher, and school held constant.

Hypothesis 11. Students who chose science careers did not differ in science interest from students who did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

Hypothesis 12. Students who made projects did not differ in science interest from students who did not make projects whether they chose science careers or did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

A summary of the experimental data for the subgroups and the results of the analysis of covariance is reported in Table VIII.

In order to be significant at the five percent level of confidence, an F-value with 1 and 34 degrees of freedom must be 4.13 (76, p. 421). For the three hypotheses, F-values of 0.09, 1.22, and 0.64 respectively were obtained and all three are nonsignificant; therefore, the null hypotheses 10, 11 and 12 are accepted.

Teacher Ratings

The null hypotheses 13, 14, and 15 as stated in Chapter I are
Table VIII. Summary of experimental interest data for ninth grade project groups stratified for career choice.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>( \bar{Y}^* )</th>
<th>( \bar{X}_1^* )</th>
<th>( \bar{X}_2^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>24.30</td>
<td>119.80</td>
<td>25.90</td>
</tr>
<tr>
<td>No Science Career</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>19.10</td>
<td>123.60</td>
<td>20.80</td>
</tr>
<tr>
<td>Subtotal</td>
<td>20</td>
<td>21.70</td>
<td>121.70</td>
<td>23.35</td>
</tr>
<tr>
<td>No Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>25.50</td>
<td>114.60</td>
<td>26.10</td>
</tr>
<tr>
<td>No Science Career</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>15.50</td>
<td>111.10</td>
<td>18.20</td>
</tr>
<tr>
<td>Subtotal</td>
<td>20</td>
<td>20.50</td>
<td>112.85</td>
<td>22.15</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>21.10</td>
<td>117.28</td>
<td>22.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Residuals</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>( F_{1,34} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>2.48500</td>
<td>2.48500</td>
<td>0.09</td>
</tr>
<tr>
<td>Career</td>
<td>1</td>
<td>34.15722</td>
<td>34.15722</td>
<td>1.22</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>18.10045</td>
<td>18.10045</td>
<td>0.64</td>
</tr>
<tr>
<td>Within</td>
<td>34</td>
<td>955.89999</td>
<td>28.11470</td>
<td></td>
</tr>
</tbody>
</table>

* \( Y^* \) Occupational Interest Inventory Post-test

\( X_1^* \) IQ Scores

\( X_2^* \) Occupational Interest Inventory Pretest
restated here and the analysis of covariance multiple classification applied, in order to test for significance (76, p. 352). Significant tests at both the one and five percent levels are reported.

Hypothesis 13. Students who made projects did not differ in teacher ratings from students who did not make projects, with pretest, IQ scores, experience, teacher, and school held constant.

Hypothesis 14. Students who chose science careers did not differ in teacher ratings from students who did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

Hypothesis 15. Students who made projects did not differ in teacher ratings from students who did not make projects whether they chose science careers or did not choose science careers, with pretest, IQ scores, experience, teacher, and school held constant.

A mean of 13.44 and a standard deviation of 3.85 were calculated from teacher (X)'s ratings of students' understanding of both process and content in science. The ratings were then standardized at a mean of 50 and standard deviation of 10 as recommended by Walker (73, p. 103).
A summary of the experimental data for the subgroups and the results of the analysis of covariance is reported in Table IX.

In order to be significant at the five percent level of confidence, an F-value with 1 and 34 degrees of freedom must be 4.13 (76, p. 421). For hypotheses 13, 14, and 15, F-values of 0.09, 0.34, and 1.23 respectively were obtained and all three are non-significant; therefore, the null hypotheses 13, 14, and 15 are accepted.

**Type of Project**

**Sample Selection**

The type of project made was selected as the third control variable to study. The 952 students who participated in the study were grouped according to whether they made investigations, constructions, demonstrations, or no project at all as shown in Table X.

Samples of equal size were selected from each of the subgroups in order to avoid disproportionality (76, p. 103, 211). A random sample of 50 was selected for each subgroup for a total sample of 200.
Table IX. Summary of experimental teacher rating data for ninth grade project groups stratified for career choice.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>Y*</th>
<th>X1*</th>
<th>X2*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>20</td>
<td>59.00</td>
<td>119.80</td>
<td>57.20</td>
</tr>
<tr>
<td>No Science Career</td>
<td>10</td>
<td>54.00</td>
<td>123.60</td>
<td>54.60</td>
</tr>
<tr>
<td>Subtotal</td>
<td>20</td>
<td>56.50</td>
<td>121.70</td>
<td>55.90</td>
</tr>
<tr>
<td>No Ninth Grade Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Career</td>
<td>10</td>
<td>50.10</td>
<td>114.60</td>
<td>49.80</td>
</tr>
<tr>
<td>No Science Career</td>
<td>10</td>
<td>48.40</td>
<td>111.10</td>
<td>47.00</td>
</tr>
<tr>
<td>Subtotal</td>
<td>20</td>
<td>49.25</td>
<td>112.85</td>
<td>48.40</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>52.88</td>
<td>117.28</td>
<td>52.15</td>
</tr>
</tbody>
</table>

Source of Residuals

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F1, 34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>2.28128</td>
<td>2.28128</td>
<td>0.09</td>
</tr>
<tr>
<td>Career</td>
<td>1</td>
<td>8.22420</td>
<td>8.22420</td>
<td>0.34</td>
</tr>
<tr>
<td>Interaction</td>
<td>1</td>
<td>29.98795</td>
<td>29.98795</td>
<td>1.23</td>
</tr>
<tr>
<td>Within</td>
<td>34</td>
<td>827.87285</td>
<td>24.349200</td>
<td></td>
</tr>
</tbody>
</table>

*Y Post-Project Teacher Rating

\bar{X}_1 IQ Scores

\bar{X}_2 Pre-Project Teacher Rating
Table X. Number of students making projects by type of project made.

<table>
<thead>
<tr>
<th>Type of Project</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation</td>
<td>71</td>
</tr>
<tr>
<td>Construction</td>
<td>85</td>
</tr>
<tr>
<td>Demonstration</td>
<td>57</td>
</tr>
<tr>
<td>None</td>
<td>739</td>
</tr>
<tr>
<td>Total</td>
<td>952</td>
</tr>
</tbody>
</table>

Achievement

The null hypothesis 16 as stated in Chapter I is restated here and the analysis of covariance single classification applied in order to test for significance (76, p. 344). A significant test at both the one and five percent levels will be reported.

Hypothesis 16. Students who made investigation projects, construction projects, demonstration projects, or none at all did not differ in achievement, with pretest and IQ scores held constant.

A summary of experimental data for the subgroups and the results of the analysis of covariance is reported in Table XI.

In order to be significant at the five percent level of confidence, an F-value with 3 and 194 degrees of freedom must be 2.65
Table XI. Summary of experimental achievement data according to type of project made.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>$\bar{Y}^*$</th>
<th>$\bar{X}_1^*$</th>
<th>$\bar{X}_2^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation</td>
<td>50</td>
<td>29.62</td>
<td>114.52</td>
<td>41.16</td>
</tr>
<tr>
<td>Construction</td>
<td>50</td>
<td>25.18</td>
<td>109.32</td>
<td>39.84</td>
</tr>
<tr>
<td>Demonstration</td>
<td>50</td>
<td>25.14</td>
<td>106.50</td>
<td>39.52</td>
</tr>
<tr>
<td>None</td>
<td>50</td>
<td>27.84</td>
<td>109.14</td>
<td>40.36</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>200</td>
<td>26.95</td>
<td>109.87</td>
<td>40.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>$F_{3,194}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>197</td>
<td>6870.199</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subgroups</td>
<td>194</td>
<td>6506.440</td>
<td>33.5835</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>3</td>
<td>363.759</td>
<td>121.25300</td>
<td>3.62</td>
</tr>
</tbody>
</table>

$*Y$ STEP 2B Post-test
$X_1$ IQ Scores
$X_2$ STEP 3A Pretest

** Significant at the 5% level of confidence
An F-value of 3.62 was obtained and is significant beyond the five percent level of confidence; therefore, the null hypothesis 16 is rejected.

Inspection of the subgroups means of all variables as shown in Table XI reveals that the students who made investigation type projects surpassed all other subgroups with regard to both control variables. Possibly a part of the difference between the criterion means was caused by the fact that the students who made investigations are a superior group on the basis of the control variables (76, p. 348).

The within regression equation was used to adjust the criterion means (76, p. 348). The adjustment of each criterion mean was calculated and the appropriate adjustments made. The value of .91 was subtracted from the investigation subgroup mean. The values of .23, .67, and .01 respectively were added to the construction, demonstration, and none subgroup means. The adjusted criterion means are shown in Table XII.

The Student's t-test was then conducted on the adjusted criterion means in order to aid in the interpretation of the data (76, p. 183).

Six sub-hypotheses were stated as follows:

Hypothesis 16a. Students who made investigation projects did not differ in achievement from students
Table XII. Summary of experimental achievement data of criterion and adjusted criterion means according to type of project made.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>( \bar{Y}^* )</th>
<th>( \bar{Y}^*_{a} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation</td>
<td>50</td>
<td>29.62</td>
<td>28.71</td>
</tr>
<tr>
<td>Construction</td>
<td>50</td>
<td>25.18</td>
<td>25.41</td>
</tr>
<tr>
<td>Demonstration</td>
<td>50</td>
<td>25.14</td>
<td>25.81</td>
</tr>
<tr>
<td>None</td>
<td>50</td>
<td>27.84</td>
<td>27.85</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>26.95</td>
<td>26.95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Adjusted Criterion Means</th>
<th>( t ) ( \frac{}{49\text{df}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation vs Construction</td>
<td>28.71 vs 25.41</td>
<td>2.20 **</td>
</tr>
<tr>
<td>Investigation vs Demonstration</td>
<td>28.71 vs 25.81</td>
<td>1.82 n. s.</td>
</tr>
<tr>
<td>Investigation vs None</td>
<td>28.71 vs 27.85</td>
<td>0.52 n. s.</td>
</tr>
<tr>
<td>Construction vs Demonstration</td>
<td>25.41 vs 25.81</td>
<td>0.31 n. s.</td>
</tr>
<tr>
<td>Construction vs None</td>
<td>25.41 vs 27.85</td>
<td>1.77 n. s.</td>
</tr>
<tr>
<td>Demonstration vs None</td>
<td>25.81 vs 27.85</td>
<td>1.39 n. s.</td>
</tr>
</tbody>
</table>

\( \bar{Y} \) STEP 2B Post-test
\( \bar{Y}_{a} \) STEP 2B Post-test, Adjusted

** Significant at the 5% level of confidence
who made construction projects.

Hypothesis 16b. Students who made investigations did not differ in achievement from students who made demonstration projects.

Hypothesis 16c. Students who made investigations did not differ in achievement from students who did not make a project.

Hypothesis 16d. Students who made construction projects did not differ in achievement from students who made demonstration projects.

Hypothesis 16e. Students who made construction projects did not differ in achievement from students who did not make a project.

Hypothesis 16f. Students who made demonstration projects did not differ in achievement from students who did not make a project.

A summary of the criterion and adjusted criterion means for the subgroups and the results of the Student's t-test is shown in Table XII.

In order to be significant at the five percent level of confidence, a t-value with 49 degrees of freedom must be 2.10 (76, p. 418). For all hypotheses except 16a, t-values of less than 2.10 were obtained and are nonsignificant; therefore the null hypotheses 16b, 16c, 16d,
16e, and 16f are accepted.

A t-value of 2.20 was obtained for hypothesis 16a and is significant beyond the five percent level of confidence; therefore, the null hypothesis 16a is rejected.

Wert (76, p. 183) and Linquist (46, p. 327) recommend computing t-values between any two adjusted means when a significant F-value has been found in single classification analysis of covariance.

Wert (76, p. 183) has noted the following caution:

It should be noted however, that the individual mean difference can no longer be regarded as random observations from a normally distributed population since the F-value found was significant. . . . Because of these considerations, it is probably appropriate to consider significant t-values between the specific group means only as indications of areas where additional research may be desirable.

Further reference will be made to the interpretation of the conclusions regarding hypothesis 16 in Chapter V.

Interest

The null hypothesis 17 as stated in Chapter I is restated here and the analysis of covariance applied in order to test for significance. A significant test at both the one and five percent levels will be reported.

Hypothesis 17. Students who made investigation projects, construction projects, demonstration
projects, or none at all did not differ in science interest, with pretest and IQ scores held constant.

A summary of the experimental data is reported in Table XIII.

In order to be significant at the five percent level of confidence, an F-value with 3 and 194 degrees of freedom must be 2.65 (76, p. 422). An F-value of 1.04 was obtained and is nonsignificant; therefore, the null hypothesis is accepted.

Motivation Factors: Awards

Sample Selection

The type of award received was selected as the fourth control variable to study. The 952 students who participated in the study were grouped according to whether they received recognition awards, participation awards, no awards, or whether they did not make a project at all as shown in Table XIV.

Recognition awards were considered the award winners representing the traditional silver and gold awards and the participation awards were considered the traditional red awards as recommended by OMSI (57, p. 3) and defined in Chapter I.

Samples of equal size were drawn in order to avoid disproportionality (76, p. 103, 211). A random sample of 20 was selected from each subgroup for a total sample of 80.
Table XIII. Summary of experimental interest data according to type of project made.

<table>
<thead>
<tr>
<th>Type of Project</th>
<th>k</th>
<th>$\bar{Y}^*$</th>
<th>$\bar{X}_1^*$</th>
<th>$\bar{X}_2^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation</td>
<td>50</td>
<td>20.30</td>
<td>114.52</td>
<td>21.70</td>
</tr>
<tr>
<td>Construction</td>
<td>50</td>
<td>19.60</td>
<td>109.32</td>
<td>19.56</td>
</tr>
<tr>
<td>Demonstration</td>
<td>50</td>
<td>20.26</td>
<td>106.50</td>
<td>20.84</td>
</tr>
<tr>
<td>No Project</td>
<td>50</td>
<td>20.80</td>
<td>109.14</td>
<td>20.68</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>20.24</td>
<td>109.87</td>
<td>20.70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Residuals</th>
<th>( F_{3,194} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>df</td>
<td>SS</td>
<td>MS</td>
</tr>
<tr>
<td>Total</td>
<td>197</td>
<td>3.442.784</td>
</tr>
<tr>
<td>Within</td>
<td>194</td>
<td>3.388.103</td>
</tr>
<tr>
<td>Difference</td>
<td>3</td>
<td>54.681</td>
</tr>
</tbody>
</table>

$^*Y$ Occupational Interest Inventory Post-test

$\bar{X}_1$ IQ Scores

$\bar{X}_2$ Occupational Interest Inventory Pretest
Table XIV. Number of students making projects by type of awards received.

<table>
<thead>
<tr>
<th>Type of Award</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognition</td>
<td>26</td>
</tr>
<tr>
<td>Participation</td>
<td>88</td>
</tr>
<tr>
<td>No Award</td>
<td>99</td>
</tr>
<tr>
<td>No Project</td>
<td>739</td>
</tr>
<tr>
<td>Total</td>
<td>952</td>
</tr>
</tbody>
</table>

Achievement

The null hypothesis 18 as stated in Chapter I is restated here and the analysis of covariance single classification applied in order to test for significance. A significant test at both the one and five percent levels of confidence will be reported.

Hypothesis 18. Students who received Science Fair recognition awards did not differ in achievement from students who received participation awards, no awards, or who did not make a project, with pretest and IQ scores held constant.

A summary of the experimental data is shown in Table XV.

In order to be significant at the five percent level of confidence, an F-value with 3 and 74 degrees of freedom must be 2.73 (76, p. 422). An F-value of 1.91 was obtained and is nonsignificant;
Table XV. Summary of experimental achievement data according to awards received.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>Y*</th>
<th>X1*</th>
<th>X2*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognition</td>
<td>20</td>
<td>31.15</td>
<td>116.90</td>
<td>43.90</td>
</tr>
<tr>
<td>Participation</td>
<td>20</td>
<td>28.70</td>
<td>112.80</td>
<td>40.20</td>
</tr>
<tr>
<td>No Award</td>
<td>20</td>
<td>22.35</td>
<td>103.35</td>
<td>36.80</td>
</tr>
<tr>
<td>No Project</td>
<td>20</td>
<td>28.45</td>
<td>111.05</td>
<td>40.65</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>27.66</td>
<td>110.25</td>
<td>40.39</td>
</tr>
</tbody>
</table>

Source of Variation

<table>
<thead>
<tr>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F 3,74</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>77</td>
<td>2.580.23</td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>74</td>
<td>2.395.13</td>
<td>32.36662</td>
</tr>
</tbody>
</table>

*Y STEP 2B Post-test

X1 IQ Scores

X2 STEP 3A Pretest
therefore, the null hypothesis 18 is accepted.

**Interest**

The null hypothesis 19 as stated in Chapter I is restated here and the analysis of covariance single classification applied in order to test for significance. A significant test at both the one and five percent levels of confidence will be reported.

**Hypothesis 19.** Students who received Science Fair recognition awards did not differ in science interest from students who received participation awards, no awards, or who did not make a project, with pretest and IQ scores held constant.

A summary of the experimental data is shown in Table XVI.

In order to be significant at the five percent level of confidence, an F-value with 3 and 74 degrees of freedom must be 2.73 (76, p. 422). An F-value of 0.53 was obtained and is nonsignificant; therefore, the null hypothesis 19 is accepted.

**Motivation Factors**

The remaining data on motivation factors was examined through the use of simple percentages rather than statistical inference. The data were collected primarily to assist in the interpretation of the
Table XVI. Summary of experimental interest data according to awards received.

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>k</th>
<th>$\bar{Y}$*</th>
<th>$\bar{X}_1$*</th>
<th>$\bar{X}_2$*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognition</td>
<td>20</td>
<td>20.60</td>
<td>116.90</td>
<td>22.00</td>
</tr>
<tr>
<td>Participation</td>
<td>20</td>
<td>20.70</td>
<td>112.80</td>
<td>22.15</td>
</tr>
<tr>
<td>No Award</td>
<td>20</td>
<td>16.95</td>
<td>103.35</td>
<td>16.10</td>
</tr>
<tr>
<td>No Project</td>
<td>20</td>
<td>20.05</td>
<td>111.05</td>
<td>20.80</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>19.58</td>
<td>110.25</td>
<td>20.26</td>
</tr>
</tbody>
</table>

Source of Variation          | Residuals |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
</tr>
<tr>
<td>Within</td>
<td>74</td>
</tr>
<tr>
<td>Difference</td>
<td>3</td>
</tr>
</tbody>
</table>

*Y Occupational Interest Inventory Post-test

$\bar{X}_1$ IQ Scores

$\bar{X}_2$ Occupational Interest Inventory Post-test
statistical tests and to assist in making recommendations for future study.

The relationships between teacher-school motivational factors and ninth grade project makers, student motivational factors and the ninth grade project groups, students' reaction to project making, and the students project making record and career choice were examined. Various other combinations were examined but no meaningful relationships were found.

**Teacher-School Motivation Factors**

The Teacher Inventory was given primarily to assess the teachers' attitude towards the objectives of project making activities as proposed by OMSI (57, p. 2), and to assess the degree that the teacher and school attempt to involve students in science project activities. As a part of the Student Inventory, questions were asked which were used to validate the Teacher Inventory.

The teacher-school motivation factors were defined in Chapter I as those directions, requirements, encouragements, attitudes, and conveniences of time and facilities provided by the teacher and the school which may effect a student's participation in project making activities. The results of the Teacher Inventory and Student Inventory were used to classify the teacher-school motivation factors as follows:
1. Required, class time, grades, fair: The teacher required the students to make a project, allowed some class time to make the project, gave grade credit for the project, and the school provided an organized Science Fair for display of the projects.

2. Required, class time, grades: The teacher required the students to make a project, allowed some class time to make the project, gave grade credit for the project, but the school did not provide for an organized science fair for display of the projects.

3. Optional, class time, grades, fair: The teacher gave the students an option of making a project, allowed some class time to make the project, gave grade credit for the project, and the school provided an organized Science Fair for display of the projects.

4. Optional, class time, grades: The teacher gave the students an option of making a project, allowed some class time to make the project, gave grade credit for the project, but the school did not provide an organized Science Fair for display of the projects.

5. No projects, not enough time: Project making was not a part of the teacher's science program because the teacher felt that while project making was worthwhile, there was
not enough time to develop projects properly. The school
did not provide an organized Science Fair.

6. No projects, better ways: Project making was not a part
of the teacher's science program because the teacher felt
that there are better ways to reach his objectives. The
school did not provide for an organized Science Fair.

7. No projects, waste of time: Project making was not a
part of the teacher's science program because the teacher
felt that projects were a waste of time. The school did
not provide for an organized Science Fair.

A summary of the relationship of teacher-school motivation
factors and ninth grade project makers is shown in Table XVII. A
direct relationship exists between the degree of teacher-school moti-
vation factors influencing the student and the percentage of students
in each subgroup making projects.

In the subgroups where a project is required, 97 and 82 percent
of the students made projects compared to 28 and 6 percent in the
subgroups where a project was optional.

In the subgroups where some kind of fair is provided, 97 and
28 percent of the students made projects compared to 82 and 6 per-
cent in the subgroups where a fair was not provided.

It is obvious that very few students make science projects un-
less the teacher and the school actively support and promote such
projects.
Table XVII. Relationship of teacher-school motivation factors and ninth grade project makers.

<table>
<thead>
<tr>
<th>Teacher-School Motivation Factors</th>
<th>Number of Teachers</th>
<th>Number of Projects</th>
<th>Percent of Subgroups</th>
<th>Number in Subgroups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Required, class time, grades, fair</td>
<td>1</td>
<td>72</td>
<td>97.3</td>
<td>74</td>
</tr>
<tr>
<td>2. Required, class time, grades</td>
<td>2</td>
<td>91</td>
<td>82.0</td>
<td>111</td>
</tr>
<tr>
<td>3. Optional, class time, grades, fair</td>
<td>2</td>
<td>40</td>
<td>28.2</td>
<td>142</td>
</tr>
<tr>
<td>4. Optional, class time, grades</td>
<td>1</td>
<td>5</td>
<td>6.3</td>
<td>80</td>
</tr>
<tr>
<td>5. No projects, not enough time</td>
<td>4</td>
<td>2</td>
<td>0.8</td>
<td>251</td>
</tr>
<tr>
<td>6. No projects, better ways</td>
<td>3</td>
<td>2</td>
<td>1.2</td>
<td>165</td>
</tr>
<tr>
<td>7. No projects, waste of time</td>
<td>4</td>
<td>1</td>
<td>0.8</td>
<td>129</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>213</td>
<td>952</td>
<td></td>
</tr>
</tbody>
</table>
Student-Motivation Factors

Student motivation factors were defined in Chapter I as those reasons given by the student as to why he did or did not make a science project.

As a part of the Student Inventory, the students were asked to indicate why they made a project or why they did not make a project. Of the following five choices which the students were asked to respond to, none of the 952 students in the study indicated that their parents were a factor:

Required by teacher but I would have made a project anyway.
Required by teacher or I would not have made a project.
Directed by parents to make a project but I would have made one anyway.
Directed by parents to make a project or I would not have made one.
I made a project completely on a volunteer basis.

Students who did not make projects were asked to respond to one of the first two and one of the last three of the following factors:

A science project was required but I didn't make one.
A science project was not required.
I did not make a science project because I had no interest.
I did not make a science project because of lack of time.
I did not make a science project because I couldn't decide what to do.

Of the 185 students who were required to make a project, only 22 failed to do so.

The student motivation factors were then tabulated into the following categories:

**Ninth Grade Project**
1. Teacher required but would have.
2. Teacher required or wouldn't have.
3. Volunteer.

**No Ninth Grade Project**
1. No interest.
2. Lack of time.
3. Couldn't decide.

A summary of the relationship between the ninth grade project subgroups and student motivational factors is shown in Table XVIII. Fifty percent of the students in the total sample reported that they did not make projects because of lack of interest.

Forty-three percent of the project makers either volunteered or reported that they would have volunteered if no requirements had been set; however, reviewing the data in Table XVII, it appears unlikely that such a large percentage would have responded without strong teacher-school motivation factors present. Fifty-seven
Table XVIII. Relationship of students who made ninth grade projects, students who did not make ninth grade projects, and student motivation factors.

<table>
<thead>
<tr>
<th>Student Motivation Factors</th>
<th>Number in Subgroup</th>
<th>% of Subgroup</th>
<th>% of Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ninth Grade Project</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Required, But Would Have</td>
<td>42</td>
<td>19.7</td>
<td>4.4</td>
</tr>
<tr>
<td>Teacher Required, or Would not Have</td>
<td>121</td>
<td>56.8</td>
<td>12.7</td>
</tr>
<tr>
<td>Volunteer</td>
<td>50</td>
<td>23.5</td>
<td>5.3</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>213</td>
<td>100.0</td>
<td>22.4</td>
</tr>
<tr>
<td><strong>No Ninth Grade Project</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Interest</td>
<td>474</td>
<td>64.2</td>
<td>49.8</td>
</tr>
<tr>
<td>Lack of Time</td>
<td>168</td>
<td>22.7</td>
<td>17.6</td>
</tr>
<tr>
<td>Couldn't Decide</td>
<td>97</td>
<td>13.1</td>
<td>10.2</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>739</td>
<td>100.0</td>
<td>77.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>952</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
percent made a project only because it was required.

With other teacher-school motivation factors approximately equal, 24 percent of the students in the optional subgroups made projects compared to 20 percent of the students in the required subgroups who reported that they would have volunteered.

Students' Reactions

As a part of the Student Inventory, the students were asked to indicate how they felt about the project when it was completed. Of the following five reactions, they were asked to choose one of the first two reactions and one of the last three reactions:

I enjoyed making the project.
I did not enjoy making the project.
I learned something about science from making the project.
I did not learn much about science from making the project.
The project was a waste of time.

The students' reactions were then tabulated into the following categories:

1. Enjoyed, learned.
2. Enjoyed, did not learn.
3. Enjoyed, waste of time.
4. Did not enjoy, learned.
5. Did not enjoy, did not learn.
6. Did not enjoy, waste of time.

A summary of the students' reactions to project making is shown in Table XIX. Sixty-six percent reported that they had enjoyed making the project and 65 percent reported they had learned from the experience. Thirty-four percent did not enjoy making the project and 35 percent either reported that they had not learned from it or felt the project was a waste of time.

Table XIX. Students' reactions to project making.

<table>
<thead>
<tr>
<th>Students' Reactions</th>
<th>Number of Subgroups</th>
<th>Percent of Ninth Grade Project Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enjoyed, learned</td>
<td>107</td>
<td>50.2</td>
</tr>
<tr>
<td>2. Enjoyed, did not learn</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>3. Enjoyed, waste of time</td>
<td>31</td>
<td>14.6</td>
</tr>
<tr>
<td>4. Did not enjoy, learned</td>
<td>32</td>
<td>15.0</td>
</tr>
<tr>
<td>5. Did not enjoy, did not learn</td>
<td>14</td>
<td>6.6</td>
</tr>
<tr>
<td>6. Did not enjoy, waste of time</td>
<td>26</td>
<td>12.2</td>
</tr>
<tr>
<td>Total</td>
<td>213</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Career Choice and Project Record

As a part of the Student Inventory, the students were asked to indicate whether or not they planned on a science career at that time. If they did not plan on a science career, they were asked to choose one of the following:

I plan on a personal-social occupation such as domestic service, personal service, social service, teaching, law and law enforcement, or health and medical service.

I plan on a natural occupation such as farming and ranching, raising and caring for animals, gardening and greenhouse care, fish and game, or lumbering and forestry.

I plan on a mechanical occupation such as maintenance, machine operation, repairing, construction work, order signing.

I plan on a business occupation such as selling and buying, bookkeeping and accounting, clerical, shipping and distributing, training and supervision, or management and control.

I plan on a career in the arts such as art crafts, art objects, painting and drawing, decorating and landscaping, drama, literature, radio, or musical performance.

If none of the career categories were checked or if multiple
choices were made, it was assumed that the student was undecided at that time. The students' choices were then tabulated into the following categories:

1. Science
2. Personal-Social
3. Natural
4. Mechanical
5. Business
6. Arts
7. Undecided

A summary of the relationship between the students' project record and career choice is shown in Table XX. There is a direct relationship between the number of years that a student has participated in project making and his choice of science as a career. The data do not reveal whether the career orientation resulted from the project activity or vice versa.

Inverse relationships exist between the students' project record and the personal-social and mechanical career categories. The reasons for these relationships were not discovered in this study.

The type of project made was examined in various combinations with the students' career choice and project record but no meaningful relationships could be found.
Table XX. Relationship of students' project record and students' career choice.

<table>
<thead>
<tr>
<th>Students Project Record</th>
<th>Students Career Choice * Percent of Project Subgroup</th>
<th>No. in Project Subgroups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One Year</td>
<td>14.2</td>
<td>26.5</td>
</tr>
<tr>
<td>Two Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23.2</td>
<td>21.1</td>
</tr>
<tr>
<td></td>
<td>28.1</td>
<td>17.5</td>
</tr>
<tr>
<td>Number in Career Subgroup</td>
<td>180</td>
<td>229</td>
</tr>
</tbody>
</table>

*A Science  
B Personal-Social  
C Natural  
D Mechanical  
E Business  
F Arts  
G Undecided
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was designed to reveal the outcomes of participation in science project activities among ninth grade science students in Multnomah County, Oregon, during the second half of the 1963-1964 school year.

A stratified sample of five public schools was selected to participate in this study. All freshmen science students, enrolled in the five schools, who were in continuous legal residence from January, 1964 to May, 1964 were participants in this study. The total sample numbered 952.

Students were pre-tested in January to establish controls over previous achievement and interest in science. Instruments utilized were: the STEP Science Test, Form 3A; and the Occupational Interest Inventory, Intermediate Battery, 1956 Revision. The Student Rating Scale was given to determine the teacher's pre-rating of the student and the Teacher Inventory was given to determine the teacher's involvement in science project activities. General intelligence was controlled by obtaining IQ scores secured earlier in the year from the SRA Primary Mental Abilities Test, Intermediate:
Form AH; and the Otis Quick Scoring Mental Ability Test, Gamma; Form EM. The IQ scores were standardized at the same mean and standard deviation.

Post-testing was conducted in May to determine subgroup differences. Instruments utilized were: the STEP Science Test, Form 2B; and the Occupational Interest Inventory, Intermediate Battery, 1956 Revision. The Student Rating Scale was given to determine the teacher's post-rating of the students and the Student Inventory was given to determine the student's involvement in science project activities.

The data were analyzed by the analysis of covariance and by descriptive percentages.

Students were stratified for experience in science project making and the analysis of covariance applied to random samples for tests of significance of differences in achievement and interest between project makers and non project makers. No significant differences in achievement or interest were found at the five percent level of confidence.

Students were stratified for choice of science as a career and the analysis of covariance applied to random samples for tests of significance of differences in achievement, interest, and teacher rating between project makers and non project makers. No significant differences in achievement, interest, or teacher ratings were
found at the five percent level of confidence.

Students were stratified for type of project made and the analysis of covariance applied to random samples for tests of significance of differences in achievement and interest between the various types of project makers and non project makers. A significant difference in achievement at the five percent level of confidence was found between investigation type project makers and construction type project makers. No significant differences in achievement at the five percent level of confidence were found between investigation type, demonstration type or non project makers. No significant differences in interest were found between any of the subgroups.

Students were stratified for type of award received and the analysis of covariance applied to random samples for tests of significance of differences in achievement and interest between the various types of award winners and non project makers. No significant differences in achievement and interest were found at the five percent level of confidence.

The students were stratified for the teacher-school motivational factors influencing their participation in science project activities. A direct relationship was found between the degree of teacher-school motivational factors influencing the student and the percentage of students making projects.

The students were stratified for the student motivational
factors influencing the student's participation in science project activities. Fifty percent of the students in the total sample reported that they did not make a science project because of lack of interest. Fifty-seven percent of the project makers made a project only because it was required.

The students were stratified for the students' reaction to project making. Sixty-six percent reported that they had enjoyed making the project and 65 percent reported that they had learned from the experience. The remaining students reported that they did not enjoy making the project and that they had not learned from it or felt the project was a waste of time.

The students were stratified for their career choice and for their record in project making. There was a direct relationship between the number of years that a student had participated in project making and his choice of science as a career. Inverse relationships existed between the students' project record and the personal-social and mechanical career categories.

Conclusions

The following conclusions were drawn from the data obtained in this study:

1. Science project making was not proven as significantly contributing to a student's achievement in science or
increase in science interest as measured by standardized tests.

2. Students who chose science as a career were not proven as significantly superior in science achievement or science interest as measured by standardized tests.

3. Students who made science projects and/or who chose science as a career were not shown to receive significantly higher ratings from a teacher who considers project making a valuable activity.

4. Students who made investigation type projects excelled in achievement over students who made construction projects but did not excel over students who made demonstrations or no project at all as measured by standardized tests. This inconsistency suggests further study.

5. The type of project made was not proven as significantly contributing to a student's interest in science as measured by standardized tests.

6. The Science Fair type of award for project making was not proven as significantly contributing to the student's achievement or interest in science as measured by standardized tests.

7. The teacher and school were the greatest contributors to motivating a student to participation in project activities.
Requirement by the teacher and a Science Fair appeared to be higher motivating factors than class time and grades.

8. A majority of project makers would not have made projects unless they were required to do so. A majority of the non-project makers lacked interest in science project activities as presently constituted.

9. A majority of students who made projects enjoyed the activity and felt that they had learned something; however, a large minority did not enjoy the activity and felt it was unproductive.

10. The larger the number of years that the student participated in project activities the greater the possibility that he has chosen science as a career and the lesser the possibility that he has chosen personal-social or mechanical careers. The data do not reveal whether the career orientation resulted from project activity or vice versa.

Recommendations

On the basis of the findings and conclusions drawn in this study it is recommended that:

1. Teachers, school administrators, and agencies who promote science project activities should re-evaluate the desirability of participation and promotion of science
project activities as presently constituted.

2. Teachers, school administrators, and agencies which continue to promote science project activities as presently constituted should be prepared to justify the cost in time and money in some other way than the students' increase in achievement and interest in science.

3. Teachers should ask themselves the following questions:
   a. Are the objectives as generally stated for project activities really worthwhile?
   b. Do the procedures of presently constituted activities lead to the attainment of these objectives?
   c. What procedures could be designed so that the activity could lead to the attainment of the objectives?
   d. What plans could be made for evaluation of the new procedures?

4. School administrators and agencies which promote science project activities should ask themselves the following questions:
   a. Are the science project activities promoted for the educational growth of students or for some other reason such as public relations?
   b. What leadership roles could be assumed which might aid the teacher in designing activities which have a
greater chance of resulting in the students' educational growth specifically in achievement and interest in science?

c. What plans could be made for evaluation of the leadership role?

5. Teacher education institutions should increase their efforts to instill a thorough understanding of the scientific enterprise in prospective science teachers. These understandings should extend to project activities.

6. Future studies should consider the following:

a. A follow-up study in some location where it is suspected that the project activities are more closely involved in the scientific enterprise.

b. A follow-up study to determine subgroup differences using new control variables such as critical thinking and attitudes.

c. A follow-up study to determine subgroup differences using new criterion variables such as critical thinking and attitudes.

d. A follow-up study to further examine the relationship of the type of project made and achievement. Some procedure will be needed to standardize the classification of projects.
e. A study to evaluate the outcomes of any new procedures in project activities which may be instituted in the future.
BIBLIOGRAPHY


APPENDIX
TEACHER INVENTORY

Name

School

To the Teacher:

You are asked to respond to the following questionnaire about a selected group of objectives for science teaching. You should try to make decisions as best you can within the limited framework of the questionnaire.

The questionnaire asks you to respond by indicating the method or methods that you employ as a means of attaining a certain objective. For this investigation, teaching methods have been limited to seven possibilities with the added opportunity to describe other methods. The eight choices of methods are defined below as a guide and to provide a common set of criteria. Please be as accurate as possible in characterizing your own teaching.

Rote - This method is characterized by memorization or drill process. Oral unison is a further example of this method.

Lecture - This method is characterized by a telling process, the giving of information or ideas.

Demonstration - This method is characterized by showing process, the showing of how to proceed, how-to-do-it, and may or may not involve student performance.

Recitation - This method is characterized by response process, the response of what is known, can be recalled, or is understood and produced when so directed.

Socratic - This method is characterized by a confrontation process in which ideas, biases, and beliefs are examined for truth.

Discussion - This method is characterized by a freedom of expression, the free interchange of ideas and information.
Problem Solving - This method is characterized by the overcoming of a physical or mental blocking which prevents an individual from attaining a goal.

Other - The teacher is free to characterize any process which he feels is a method and not represented by the previous seven.
Read carefully and make an X in the appropriate boxes.

1. Do you teach toward the objective:
   To give young people an opportunity to develop and extend their interest in science.
   □ No - If no, mark the appropriate boxes and go on to question 2.
     □ I do not feel this objective is important.
     □ I feel that this objective is important but is too difficult to achieve.
     □ I feel that this objective is not a proper part of the science curriculum at this grade level.
   □ Yes - If yes, mark the appropriate boxes and go on to question 2.

Involvement
   □ I teach directly toward this objective.
   □ I teach indirectly toward this objective.

Method employed in teaching toward this objective
   □ Rote
   □ Lecture
   □ Demonstration
   □ Recitation
   □ Socratic
   □ Discussion
   □ Problem Solving
   □ Other (briefly describe) ____________________________________________________________

Briefly describe the activities associated with the method or methods checked above.

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
2. Do you teach toward the objective:
To enable students to discover and appreciate through personal experiences some of the problems of research.

☐ No - If no, mark the appropriate boxes and go on to question 3.

☐ I do not feel this objective is important.

☐ I feel this objective is important but is too difficult to achieve.

☐ I feel that this objective is not a proper part of the science curriculum at this grade level.

☐ Yes - If yes, mark the appropriate boxes and go on to question 3.

Involvement

☐ I teach directly toward this objective.

☐ I teach indirectly toward this objective.

Method

☐ Rote

☐ Lecture

☐ Demonstration

☐ Recitation

☐ Socratic

☐ Discussion

☐ Problem Solving

☐ Other (briefly describe) ________________________________

Briefly describe the activities associated with the method or methods checked above.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
3. Do you teach toward the objective:
   To encourage an inquiring mind, ingenuity, resourcefulness.

   □ No - If no, mark the appropriate boxes and go on to question 4.
     □ I do not feel this objective is important.
     □ I feel that this objective is important but is too difficult to achieve.
     □ I feel that this objective is not a proper part of the science curriculum at this grade level.

   □ Yes - If yes, mark the appropriate boxes and go on to question 4.

Involvement
   □ I teach directly toward this objective.
   □ I teach indirectly toward this objective.

Method
   □ Rote
   □ Lecture
   □ Demonstration
   □ Recitation
   □ Socratic
   □ Discussion
   □ Problem Solving
   □ Other (briefly describe) __________________________

Briefly describe the activities associated with the method or methods checked above.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
4. Do you teach toward the objective:
   To provide an outlet for enthusiasm and the craving for an activity that yields results.
   □ No - If no, mark the appropriate boxes and go on to question 5.
     □ I do not feel this objective is important.
     □ I feel that this objective is important but is too difficult to achieve.
     □ I feel that this objective is not a proper part of the science curriculum at this grade level.
   □ Yes - If yes, mark the appropriate boxes and go on to question 5.

   Involvement
   □ I teach directly toward this objective.
   □ I teach indirectly toward this objective.

   Method
   □ Rote
   □ Lecture
   □ Demonstration
   □ Recitation
   □ Socratic
   □ Discussion
   □ Problem Solving
   □ Other (briefly describe) ____________________________________________.

   Briefly describe the activities associated with the method or methods checked above.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
5. Do you teach toward the objective:
   To develop the habit of persistence regardless of initial success.
   □ No - If no, mark the appropriate boxes and go on to question 6.
     □ I do not feel this objective is important.
     □ I feel that this objective is important but is too difficult to achieve.
     □ I feel that this objective is not a proper part of the science curriculum.
   □ Yes - If yes, mark the appropriate boxes and go on to question 6.

   Involvement
   □ I teach directly toward this objective.
   □ I teach indirectly toward this objective.

   Method
   □ Rote
   □ Lecture
   □ Demonstration
   □ Recitation
   □ Socratic
   □ Discussion
   □ Problem Solving
   □ Other (briefly describe) ________________________________.

   Briefly describe the activities associated with the method or methods checked above.

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
6. Do you teach toward the objective:
To bring to light qualities and abilities that otherwise might not be discovered.

☐ No - If no, mark the appropriate boxes and go on to question 7.

☐ I do not feel this objective is important.

☐ I feel that this objective is important but is too difficult to achieve.

☐ I feel that this objective is not a proper part of the science curriculum at this grade level.

☐ Yes - If yes, mark the appropriate boxes and go on to question 7.

Involvement
☐ I teach directly toward this objective.

☐ I teach indirectly toward this objective.

Method
☐ Rote

☐ Lecture

☐ Demonstration

☐ Recitation

☐ Socratic

☐ Discussion

☐ Problem Solving

☐ Other (briefly describe) ____________________________________________

Briefly describe the activities associated with the method or methods checked above.

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________
7. Do you teach toward the objective:
   To make science concrete rather than abstract. To have students work on problems first-hand instead of merely verbalizing.

   □ No - If no, mark the appropriate boxes and go on to question 8.
      □ I do not feel this objective is important.
      □ I feel that this objective is important but is too difficult to achieve.
      □ I feel that this objective is not a proper part of the science curriculum at this grade level.

   □ Yes - If yes, mark the appropriate boxes and go on to question 8.

   Involvement
      □ I teach directly toward this objective.
      □ I teach indirectly toward this objective.

   Method
      □ Rote
      □ Lecture
      □ Demonstration
      □ Recitation
      □ Socratic
      □ Discussion
      □ Problem Solving
      □ Other (briefly describe) ________________________________

   Briefly describe the activities associated with the method or methods checked above.

   _____________________________________________________________
   _____________________________________________________________
   _____________________________________________________________
   _____________________________________________________________
   _____________________________________________________________
8. Do you teach toward the objective:
To overcome one of the greatest problems in our country today . . . . the scientific illiteracy of its people.

☐ No - If no, mark the appropriate boxes and go on to question 9.

☐ I do not feel this objective is important.

☐ I feel that this objective is important but is too difficult to achieve.

☐ I feel that this objective is not a proper part of the science curriculum at this grade level.

☐ Yes - If yes, mark the appropriate boxes and go on to question 9.

Involvement

☐ I teach directly toward this objective.

☐ I teach indirectly toward this objective.

Method

☐ Rote

☐ Lecture

☐ Demonstration

☐ Recitation

☐ Socratic

☐ Discussion

☐ Problem Solving

☐ Other (briefly describe) ___________________________________________________________________________.

Briefly describe the activities associated with the method or methods checked above.

_____________________________________________________________________________________________

_____________________________________________________________________________________________

_____________________________________________________________________________________________

_____________________________________________________________________________________________
9. Do you teach toward the objective:
To help students to work as scientists do, and teach them through their work the joy of finding out something for themselves.

☐ No - If no, mark the appropriate boxes and go on to question 10.

☐ I do not feel this objective is important.

☐ I feel that this objective is important but is too difficult to achieve.

☐ I feel that this objective is not a proper part of the science curriculum at this grade level.

☐ Yes - If yes, mark the appropriate boxes and go on to question 10.

Involvement

☐ I teach directly toward this objective.

☐ I teach indirectly toward this objective.

Method

☐ Rote

☐ Lecture

☐ Demonstration

☐ Recitation

☐ Socratic

☐ Discussion

☐ Problem Solving

☐ Other (briefly describe) ________________________________

Briefly describe the activities associated with the method or methods checked above.
10. Do your students make science projects?
   □ No - If no, mark the appropriate boxes and go on to question 11.
   □ I feel projects are a waste of time.
   □ I feel I can best reach my objectives in another manner.
   □ I feel that projects are worthwhile but we don't have time to develop them properly.
   □ Yes - If yes, mark the appropriate boxes and go on to question 11.
   □ I require my students to make a science project.
   □ I give my students an option of making a project or not making one.
   □ I encourage my students to make a project on their own.
   □ I allow class time for project work.
   □ I give grade credit for project work.

11. Do your students participate in a Science Fair?
   □ No -
   □ We hold a non-competitive school or department display.
   □ Yes -
   □ School or district
   □ OMSI County
   □ OMSI Northwest

12. Briefly describe your feelings about science project work and Science Fairs which you may have been unable to express in the above questionnaire.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
To the Student:

You are asked to respond to the following questionnaire about your participation in science project making and Science Fair participation. You should try to be careful and accurate and to remember details as much as possible. The data from this questionnaire will be used in an important study and your participation is appreciated.

-------------------

Read carefully and make an X in the appropriate boxes.

-------------------
1. Did you attend your present school for grades seven and eight?
   □ Yes - If yes, go on to question 2.
   □ No - If no, indicate schools attended and type of school, then go on to question 2.

   Name of school, grade seven ____________________________
             (     ) grade school      (     ) Jr. High     (     ) High School

   Name of school, grade eight _____________________________
             (     ) grade school      (     ) Jr. High     (     ) High School

2. Did you have a science class in grade seven?
   □ Yes - If yes, mark the appropriate boxes and then go on to question 3.
   □ science was an elective course which I chose.
   □ science was a required class.
   □ I enjoyed my science class.
   □ I did not enjoy my science class.

   □ No - If no, mark the appropriate boxes and then go on to question 3.
   □ science was an elective course which I did not take.
   □ science class was not offered.
   □ we were supposed to have a science class but we did not.

3. Did you have a science class in grade eight?
   □ Yes - If yes, mark the appropriate boxes and then go on to question 4.
   □ science was an elective course which I chose.
   □ science was a required class.
   □ I enjoyed my science class.
   □ I did not enjoy my science class.

   □ No - If no, mark the appropriate boxes and then go on to question 4.
   □ science was an elective course which I did not take.
   □ science class was not offered.
   □ we were supposed to have a science class but we did not.

4. Check the appropriate boxes regarding your current science class and then go on to question 5.
   □ the class was elective.
   □ the class was required.
   □ I enjoyed my science class.
   □ I did not enjoy my science class.
5. Did you make a science project this year?

☐ Yes - If yes, mark the appropriate boxes and then go on to question 6.

Indicate where you presented your project.

☐ I entered a school display but not a fair.
☐ I entered a School or District Science Fair.
☐ I entered a County or Regional Science Fair.
☐ I entered the Northwest Science Fair at OMSI.

Indicate the type of project you presented.

☐ Investigation of a problem.
☐ Construction or technical skill.
☐ Demonstration or illustration.

Indicate the type of award if you received one.

School or District     County or Regional
☐ Red                   ☐ Red
☐ Silver               ☐ Silver
☐ Gold                 ☐ Gold
☐ None given            ☐ None given

Indicate why you did a project.

☐ Required by teacher but I would have made a project anyway.
☐ Required by teacher or I would not have made a project.
☐ Directed by parents to make a project but I would have made one anyway.
☐ Directed by parents to make a project or I would not have made one.
☐ I made a project completely on a volunteer basis.

Indicate how you felt about the project when it was completed.

☐ I enjoyed making the project.
☐ I did not enjoy making the project.
☐ I learned something about science from making the project.
☐ I did not learn much about science from making the project.
☐ The project was a waste of time.

☐ No - If no, mark the appropriate boxes and go on to question 6.

☐ A science project was required but I didn't make one.
☐ A science project was not required.
☐ I did not make a science project because I had no interest.
☐ I did not make a science project because of lack of time.
☐ I did not make a science project because I couldn't decide what to do.
6. Did you make a science project in grade eight?

☐ Yes – If yes, mark the appropriate boxes and then go on to question 7.

Indicate where you presented your project.

☐ I entered a school display but not a fair.
☐ I entered a School or District Science Fair.
☐ I entered a County or Regional Science Fair.
☐ I entered the Northwest Science Fair at OMSI.

Indicate the type of project you presented.

☐ Investigation of a problem.
☐ Construction or technical skill.
☐ Demonstration or illustration.

Indicate the type of award if you received one.

<table>
<thead>
<tr>
<th>School or District</th>
<th>County or Regional</th>
<th>OMSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Red</td>
<td>☐ Red</td>
<td>☐ Red</td>
</tr>
<tr>
<td>☐ Silver</td>
<td>☐ Silver</td>
<td>☐ Silver</td>
</tr>
<tr>
<td>☐ Gold</td>
<td>☐ Gold</td>
<td>☐ Gold</td>
</tr>
<tr>
<td>☐ None given</td>
<td>☐ None given</td>
<td>☐ Other</td>
</tr>
</tbody>
</table>

Indicate why you did a project.

☐ Required by teacher but I would have made a project anyway.
☐ Required by teacher or I would not have made a project.
☐ Directed by parents to make a project but I would have made one anyway.
☐ Directed by parents to make a project or I would not have made one.
☐ I made a project completely on a volunteer basis.

Indicate how you felt about the project when it was completed.

☐ I enjoyed making the project.
☐ I did not enjoy making the project.
☐ I learned something about science from making the project.
☐ I did not learn much about science from making the project.
☐ The project was a waste of time.

☐ No – If no, mark the appropriate boxes and go on to question 7.

☐ A science project was required but I didn't make one.
☐ A science project was not required.
☐ I did not make a science project because I had no interest.
☐ I did not make a science project because of lack of time.
☐ I did not make a science project because I couldn't decide what to do.
7. Did you make a science project in grade seven?

- Yes - If yes, mark the appropriate boxes and go on to question 8.

Indicate where you presented your project.

- I entered a school display but not a fair.
- I entered a School or District Science Fair.
- I entered a County or Regional Science Fair.
- I entered the Northwest Science Fair at OMSI.

Indicate the type of project you presented.

- Investigation of a problem.
- Construction or technical skill.
- Demonstration or illustration.

Indicate the type of award if you received one.

<table>
<thead>
<tr>
<th>School or District</th>
<th>County or Regional</th>
<th>OMSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>Silver</td>
<td>Silver</td>
<td>Silver</td>
</tr>
<tr>
<td>Gold</td>
<td>Gold</td>
<td>Gold</td>
</tr>
<tr>
<td>None given</td>
<td>None given</td>
<td>Other</td>
</tr>
</tbody>
</table>

Indicate why you did a project.

- Required by teacher but I would have made a project anyway.
- Required by teacher or I would not have made a project.
- Directed by parents to make a project but I would have made one anyway.
- Directed by parents to make a project or I would not have made one.
- I made a project completely on a volunteer basis.

Indicate how you felt about the project when it was completed.

- I enjoyed making the project.
- I did not enjoy making the project.
- I learned something about science from making the project.
- I did not learn much about science from making the project.
- The project was a waste of time.

- No - If no, mark the appropriate boxes and go on to question 8.

- A science project was required but I didn't make one.
- A science project was not required.
- I did not make a science project because I had no interest.
- I did not make a science project because of lack of time.
- I did not make a science project because I couldn't decide what to do.
8. Do you plan a science career at this time?
   □ Yes - If yes, go on to question 9.
   □ No - If no, mark the appropriate boxes and go on to question 9.
      □ I plan on a personal-social occupation such as domestic service, personal service, social service, teaching, law and law enforcement, or health and medical service.
      □ I plan on a natural occupation such as farming and ranching, raising and caring for animals, gardening and greenhouse care, fish and game, or lumbering and forestry.
      □ I plan on a mechanical occupation such as maintenance, machine operation, repairing, construction work, or designing.
      □ I plan on a business occupation such as selling and buying, bookkeeping and accounting, clerical, shipping and distributing, training and supervision, or management and control.
      □ I plan on a career in the arts such as art crafts, art objects, painting and drawing, decorating and landscaping, drama, literature, radio, or musical performance.

9. Do you find science interesting?
   □ Yes
   □ No

Thank you for your cooperation.
### School

**STUDENT RATING SCALE**

**Teacher**

Rating by Teacher of Student Science Performance

List students in the left column and rate each student in column A and in column B by checking the numerical value you think appropriate. Please check on a number and not in between numbers.

#### Column A
Represents student's understanding of the scientific process or awareness of how to find out.

<table>
<thead>
<tr>
<th>Student's Name</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>17.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>18.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>19.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Column B
Represents student's awareness of what is known or the product of science.

<table>
<thead>
<tr>
<th>Student's Name</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>17.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>18.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>19.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20.</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Student's Name</td>
<td>Column A</td>
<td>Column B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>----------</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Represents student's understanding of the scientific process of awareness of how to find out.</td>
<td>Represents student's awareness of what is known or the product of science</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td></td>
<td>Knows a lot of science information or does not</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

JRH:pmf